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AUTHOR	Hoffer, Rina; Cantrell, Steven
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ABSTRACT

This baseline report presents classroom observation data collected during Spring 2002 in elementary and secondary mathematics and science classrooms using a sample drawn from the lowest performing schools in the district. The report also includes Los Angeles Urban Systemic Program (LAUSP) professional development workshop data from the first seven months of program implementation, December 2001 through July 2002. This report presents findings related to the quantity and quality of standards-based curriculum and instruction in mathematics and science. (KHR)

Baseline Report for the Los Angeles Urban Systemic Program in Science, Mathematics and Technology

Rina Hoffer, M.A.
Steven Cantrell, Ph.D

Los Angeles Unified School District
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Executive Summary

This baseline report presents the classroom observation data collected during Spring 2002 in elementary and secondary mathematics and science classrooms using a sample drawn from the lowest performing schools in the district. The report also includes LAUSP professional development workshop data from the first seven months of program implementation, December 2001 through July 2002. This report presents the findings related to the quantity and quality of standards-based curriculum and instruction in mathematics and science. The report will hopefully serve both program staff and district administrators in improving the infrastructure to support the enhancement of mathematics and science instruction and student success in those academic disciplines.

A brief summary of our findings follows:

How frequently are elementary teachers teaching math and science?

We found that 77% of the elementary teachers conducted a math lesson every day. Sixty percent of the elementary teachers mentioned using the pacing plan to guide their math lessons; however, a third found the pacing plan difficult to maintain. In addition to the pacing plan, teachers mentioned that SAT/9 pressures frequently determine the sequence of instruction. Teachers felt pressure to cover additional content, often at the expense of students' comprehension, since the districts' pacing plan does not address some of the topics tested on the SAT/9 until after the testing date.

Science teaching was scare. Fully 60% of the teachers failed to teach a single science lesson during our three days of observation. Only 10% of the teachers conducted a science

lesson on two or more days. Teachers claimed that the demands placed on them to implement a coherent language arts and mathematics program, did not afford them time for science instruction.

What is the quality of the elementary mathematics and science instruction?

We found that the majority of elementary teachers used traditional practices in their mathematics instruction. While there was some evidence of inquiry-based practice, it was of low quality. Our observations revealed several trends that betray a traditional, rather than inquiry-based, approach to instruction. The majority of questions teachers asked students were those requiring recall of basic information. Discussions rarely lasted more than 8 minutes. Students accomplished much of their work individually, at their desks, solving computational or procedural problems.

Where we observed science being taught, we saw a greater degree of inquiry-based instructional practices and student activities. We observed more discussions, more open-ended questions, and more opportunities for "hands-on" activities. This was especially true for teachers who conducted more than one science lesson. Teachers who told us that they did not teach many science lessons blamed the lack of resources, the lack of support, and the district's low expectations for the delivery of elementary science.

Are there any differences between the LAUSP and comparison teachers in their implementation and delivery of a mathematics and science curriculum?

In elementary classrooms more of the LAUSP teachers were observed to implement inquiry-based practices in the classroom than the comparison teachers. In mathematics, nearly twice as many LAUSP teachers used manipulatives in the classroom. In science,

the reverse occurred. We observed more inquiry strategies used by comparison teachers, particularly, discussions, open-ended questions, and opportunities for students to make observations.

What is the quantity of secondary mathematics and science courses students are receiving?

Enrollment in eighth-grade Algebra more than doubled from 2001 to 2002. The pass rate districtwide was 61%. The pass rate for the LAUSP and comparison schools was slightly lower. Between 2001 and 2002, the overall pass rate dipped by 3%. At the senior high level, the course pass rate for first year mathematics students in LAUSP was 40% and 41% among the comparison schools. Fewer students completed second year mathematics courses and still fewer completed a third year or more advanced mathematics course. Ethic differences were also observed. The pass rate for college-eligible math and science courses among Hispanic and Black students was 20% lower than the pass rate for their Asian and white counterparts.

Pass rates in first year science courses for both the LAUSP and comparison schools were lower than 50%. Fewer than 50% of students passing a first year science course continued to enroll in a second year science course.

What is the quality of the secondary mathematics and science instruction?

Instructional quality was low. Secondary mathematics and science classrooms teachers did not implement the investigative and experimentation standards nor the mathematical reasoning embedded in each of the content strands. We observed low levels of goal clarity, low levels of challenge for tasks assigned to students, and weak alignment

between the goals set and the tasks assigned. Instructional strategies and student activities in mathematics classrooms were rated similarly to those found in elementary classrooms. Student activities mainly consisted of solving basic computation problems. We saw few occasions where students were asked to solve 'real world' problems or develop inquiry skills. The questions teachers asked typically required basic recall of information, and seldom required students to use reasoning or provide evidence. Discussions occurred more often in middle school classrooms than high school classrooms, but those discussions seldom challenged students to use "higher level thinking."

We found more instances of inquiry-based practices in secondary science classrooms than we did in mathematics classrooms. Still, the majority of science lessons consisted of traditional activities. Students conducted a lab activity in 26% of the middle school classrooms and in 45% of the high school classrooms. There were higher levels of student engagement in the few classrooms where laboratory activities occurred. Where lab activity did not occur, teachers blamed a lack of resources, inadequate facilities, and low levels of district science emphasis due to the absence of mandated testing in all but senior high science classrooms.

Are there differences across school levels and between the LAUSP and comparison classrooms?

In secondary mathematics classrooms, LAUSP teachers more often utilized discussions and "hands-on" lessons, particularly at the middle school. Teachers in comparison high school classrooms asked more open-ended questions than their LAUSP counterparts.

High school teachers provided students with more opportunities to use relevant examples and 'real world' contexts in their lessons than did middle school teachers. Inquiry strategies were observed more often in the comparison classrooms.

What is the extent of Professional development offered through the LAUSP?

During the first seven months of program implementation, LAUSP provided over 200 professional development workshops in both mathematics and science to more than 2,200 teachers throughout the district. Two-thirds of the workshops were devoted to science, a few workshops were devoted to assisting mathematics and science teachers to incorporate technology into their lessons, and the balance of the workshops focused on mathematics. Over two-thirds of the professional development workshops were held at one of the six Math/Science resources centers. None of the workshops were held at LAUSP school sites.

Who is receiving the professional development offered through the LAUSP?

Overall, the LAUSP professional development predominantly served elementary teachers, and the majority of those workshops focused on science. This finding suggests that when the districts' efforts shift to include a focus on science, the teachers served by the LAUSP program will be a step ahead.

The findings in this report suggest a need to provide mathematics and science teachers with more support, and greater opportunities to learn a variety of instructional strategies that reflect Standards-based practices. Support is also need for the development of student activities that build inquiry skills.

Based on our findings we make the following recommendations:

1) If LAUSD desires science to be taught, especially at the early grades, the district needs to support standards-based science curriculum adoption and implementation. In doing so, the district will need to ensure availability of sufficient materials (books, lab materials, etc.). In elementary classrooms, the district should consider allotting a specific time devoted to science.

2) In order to assist the LAUSP in serving the professional development needs of mathematics and science teachers, the district should consider further supplementing LAUSP resources and staffing to ensure access for more of the districts' teachers to receive the professional development offered. This could happen by increasing the number of Math/Science resource centers to one per local district. Science coaches/specialists should also be considered.

3) The district should enforce the policy that students must pass two years of laboratory science and three years of mathematics prior to high school graduation.

4) The LAUSP should expand its professional development offerings to include on-site support to teachers, while maintaining the professional development offered to teachers at the Math/Science resource centers.

5) The LAUSP should increase the professional development for middle and high school teachers, particularly to teachers teaching Algebra in the eighth grade.

6) The LAUSP should offer professional development to principals in order to assist them in supporting teachers to align curriculum and instructional practice.

A Study of the Implementation of Standards-Based Mathematics and Science Curriculum, Instruction, and Assessment in Los Angeles Unified School Districts' (LAUSD) Lowest Performing Schools.

This baseline report for the Los Angeles Urban Systemic Program (LAUSP) presents observation data collected in Spring 2002. This report sets forth initial findings as to the quality and extent of Standards-based mathematics and science curriculum and instructional activities within LAUSD's lowest performing schools. This evaluation aims to assist the LAUSP in serving the professional development needs of mathematics and science teachers.

This study answers four broad questions:

- What is the nature of mathematics and science instruction in these classrooms?
- Are curricula and instruction aligned with the California Content Standards?
- Are mathematics and science teachers developing students' inquiry skills?
- Are teachers at the district's lowest performing schools participating in LAUSP's mathematics and science professional development?

Background

The National Science Foundation (NSF) launched the Urban Systemic Initiative (USI) program in 1993, applying lessons learned from the earlier State Systemic Initiative (SSI) program to the problems of inner city school systems. In 1995, LAUSD received a $15 million five-year grant under the NSF's Urban Systemic Initiatives program, a predecessor to the LAUSP. For five years, the Los Angeles Urban Systemic Initiative (LASI) undertook systemic reforms in pursuit of one simple vision: to raise student achievement levels in mathematics and science. In 2000, NSF extended the grant for a sixth year to enable LAUSD to continue its LASI. In September 2001, the NSF awarded

the LAUSD a new grant to continue the efforts it had undertaken under LASI. The new grant falls under NSF's Urban Systemic Program, the successor to the USI programs. The grant became effective September 1, 2001 and ends August 31, 2004.

Over the three years of the grant, the NSF will inject $8,970,000 into the district's mathematics and science reform efforts. For the first year of the LAUSP, NSF also awarded the district a supplemental grant of $275,000 to improve students' scientific literacy. LAUSD signed a cooperative agreement with NSF for a three-year comprehensive effort to promote Standards-based reform in mathematics, science and technology. The NSF investment was intended to be a catalyst for systemic educational change at the district's lowest performing schools, aligning Standards, curriculum, assessment, professional development, university partnerships and fiscal resources, with the goal of improving student achievement. The majority of LAUSP resources support teachers' professional development to further advance and align Standards-based curriculum and instruction in mathematics and science.

Theoretical Framework

The California Academic Content Standards in Mathematics and Science are based on the premise that all students are capable of learning rigorous mathematics and engaging in meaningful scientific investigations. The National Committee on Science Education Standards and Assessment (1992) states that science education must reflect science as it is practiced, and thus must provide students with reasoning and inquiry skills that reflect the empirical, positivist nature of science. This includes opportunities to make observations, pose relevant questions and hypothetical explanations, examine multiple sources of

information to review what is already known on the subject, plan and conduct investigations, use tools to gather, analyze, and interpret data, propose solutions, provide explanations and communicate results. Yet these activities and processes, frequently used by scientists, are not always familiar to the educator seeking to introduce scientific inquiry into the classroom.

The California Content Standards in Mathematics and Science (hereafter referred to as the Standards) require that students develop fluency in basic reasoning, problem-solving, and investigation and experimentation skills. Importantly, they also promote a conceptual understanding of fundamental mathematical and scientific concepts. The standards 31

indicate that reasoning and inquiry development should be a part of the curriculum for all grade levels, and these methods should increase in complexity to reflect the cognitive development of students.[1] The Standards place equal emphasis on the content and the communication and thinking skills required of the discipline. A failure to attend to either aspect necessarily undermines the rigor and decreases the likelihood of students attaining the required knowledge.

Although several years have passed since the adoption of the California Content Standards in Mathematics (1997) and Science (1998), there is evidence to suggest that they have not been fully implemented, nor has teachers' pedagogy become aligned with this shift in learning goals.[2] Research about the characteristics of effective learning

[1] The Standards emphasize computational and procedural skills, conceptual understanding, and problem solving. The Standards do no specify how the curriculum should be delivered but merely that teachers teach the material set forth in the Standards.
[2] Wasley,P., Donmoyer, R., Maxwell, L. (1995) Navigating change in high school science and mathematics

environments suggests that changes need to occur in science and mathematics classrooms in order to meet the challenges of aligning Standards-based curriculum and instruction.[3] As the Standards provide targets, rather than prescriptions for pedagogical practice, teachers may need models and additional support to fully implement them in the classroom. The manner in which teachers implement the Standards may provide useful information and highlight the areas of emphasis to target assistance to teachers in implementing inquiry-based practices and providing students opportunities to develop their inquiry skills.

Sample Selection

The LAUSP was designed to offer targeted assistance to the district's lowest performing schools. As of Fall 2000, seventy percent of all LAUSD schools were ranked in California's lowest performing three deciles as measured by the State's Academic Performance Index (API). We identified the two lowest performing complexes (high school feeder patterns) within each of the eleven local districts. We then randomly assigned one of the two lowest performing complexes in 10 of the 11 local districts to the LAUSP target population (146 schools) and the other complex to the comparison group (124 schools). The LAUSP additionally chose to include within the target population all schools in LAUSD's lowest performing local district.

The LAUSP target population and the comparison population share many key characteristics, however, the LAUSP target population differs from the comparison group

[3] Henningsen, M.& Stein, M.K.(1997) Mathematical tasks and student cognition, classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. Journal of Research in Mathematics Ed. 28

due to LAUSP's inclusion of the district's lowest performing local district. Subsequent analyses of classroom practice did not reveal differences between teachers from this lowest performing district and the rest of the LAUSP target population.[4] The LAUSP schools have proportionally fewer fully credentialed teachers (64% v. 72%), more African American students (14% v.9%), fewer White (2% v.4%) and Asian students (2% v.5%), and a lower School Characteristics Index (3-5 points lower).[5] The groups have similar proportions of Hispanic students (82%), English Language Learners (45-47%), parental education levels, and free/reduced lunch participants (87-88%).

[4] For this reason, the schools from LAUSD's lowest performing local district remain within the analysis. In future years, we will report growth and absolute performance for the LAUSP both with and without this group.

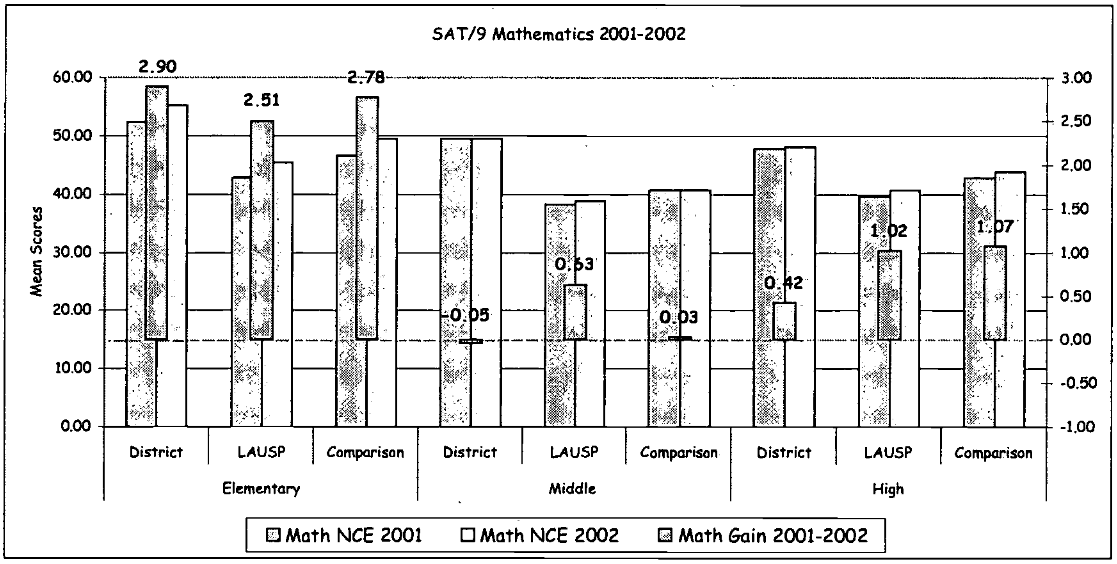
[5] The School Characteristics Index (SCI) is a composite measure of school and student level factors developed for purposes of similar school identification under California's Public School Accountability Act.

TABLE 1: SCHOOL CHARACTERISTICS AND DEMOGRAPHICS FOR DISTRICT AND SAMPLE SCHOOLS

Variable	District	LAUSP	Comparison
Teacher Credentialing Status			
All	76%	64%	72%
Elementary	73%	64%	73%
Middle	66%	60%	64%
High	73%	68%	74%
Student Ethnicity			
Am. Indian	3%	2%	2%
Asian	7%	2%	5%
African Am.	12%	14%	9%
Hispanic	72%	82%	82%
White	10%	2%	4%
Total	(N=467,610)	(N= 107,809)	(N=136,436)
Parent Education			
Not HS Graduate	23%	30%	26%
HS Graduate	17%	17%	18%
Some College	11%	8%	10%
College Graduate	12%	6%	8%
Grad School/Post Grad	4%	1%	2.2%
Unknown	32%	37%	35%
English Language Learners			
Limited English Proficiency	38%	47%	45%
Meal Plan			
Meal Program Participation	77%	88%	87%
School Characteristics Index (Mean)			
Elementary	148.6	140.7	145.4
Middle	144.6	137.0	140.1
High	142.7	134.1	139.4

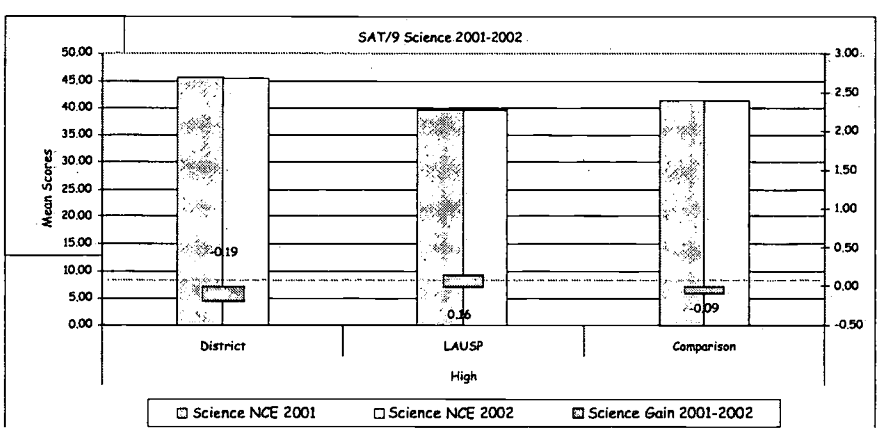
* The credentialing status includes only those secondary teachers teaching math and science.*

FIGURE 1: SAT/9 ACHIEVEMENT SCORES IN MATHEMATICS



Student mathematics performance (SAT/9 NCE) in LAUSP schools lagged the comparison schools in 2001 and 2002 by approximately four points at each schooling level (See Figure 1 above). LAUSP students made slightly larger gains than the comparison students at the middle school level (0.63 v. 0.03 NCE), but made similar gains at the elementary and senior high levels.

FIGURE 2: SAT/9 ACHIEVEMENT SCORES IN SCIENCE



At the Senior High level, comparison students' 2001 and 2002 scores (Science SAT/9 NCE) were slightly higher. Students' matched gain scores were nearly flat for both groups. The SAT/9 science test was not administered to elementary and middle school students.

Observational Sample • Schools

The initial sampling procedure consisted of probabilities proportional to size selection of schools based on school enrollment. A total of 90 schools were selected in this manner from separate strata defined by schooling level: 40 elementary schools, 30 middle schools, and 20 high schools. Since we were interested in identifying only schools with an API state rank of three or below and located within the two lowest performing complexes within each local district, we treated schools that did not meet these criteria as blanks. The remaining eligible sample consisted of 36 schools: 17 elementary schools, 12 middle schools, and 7 high schools. We then used a table of random numbers to assign one of the two lowest performing complexes in each of the 11 local districts to the LAUSP target and comparison groups.

Observational Sample • Teachers

At stage two, we randomly selected a constant number of teachers at each schooling level: four elementary teachers (one from each grade level 2-5), six middle school teachers (three each from both mathematics and science), and eight high school teachers (four each from both mathematics and science). Teachers were selected from each of the school calendar

tracks to accommodate for differences across classrooms.[6] The resulting sample consisted of 198 teachers across 36 low performing schools (API of 3 or below) from both the LAUSP and Comparison schools (See Table 2). The data collected will serve as a baseline to be compared with subsequent data collection efforts to determine LAUSP program effects on teachers' instructional practice and ultimately on student mathematics and science achievement.

TABLE 2: NUMBERS OF SAMPLE SCHOOLS AND TEACHERS

	LAUSP		Comparison		Total	
	schools	teachers	schools	teachers	schools	teachers
Elementary	8	32	9	36	17	68
Middle	8	48	4	24	12	72
High	5	40	2	16	7	56
Total	**21**	**120**	**15**	**76**	**36**	**196**

Research Questions

The observational study examines the impact of a targeted intervention, the LAUSP, on classroom instruction in mathematics and science. The study focused on both the quantity and quality of classroom instruction. In elementary classrooms, quantity is defined as the amount of instruction, measured in instructional minutes. In secondary classrooms, quantity is defined as the number of higher-level courses successfully completed within each discipline. This is measured by the percentage of students satisfying graduation and University of California (UC) and California State University (CSU) college eligibility

[6]White, J., Cantrell, S. (2001) Comparison of Student Achievement and Teacher and Student Characteristics in Multi-track and single track Traditional Calendars.

requirements. In math, we also examined the number of students enrolling and passing Algebra in the eighth grade.

We defined quality as the extent that teachers' instructional strategies and student activities align to the requirements of a Standards-based curriculum. At the secondary level we also rated overall quality using three criteria: teachers' articulated goals, lesson alignment with those goals, and the cognitive challenge of the lessons.

The following research questions frame this report:

Elementary Classrooms:

What is the frequency and duration of math and science lessons?
What is the quality of math and science instruction?
Are there differences in quality between LAUSP and comparison classrooms?

Secondary Math and Science Classrooms:

What proportion of students has completed or is on track to complete a rigorous course of study in mathematics and science?
What is the quality of math and science instruction?
Are there differences in instructional quality in middle and high classrooms school, in math and science classrooms, and in LAUSP and comparison classrooms?

Professional Development Offered by the LAUSP program

What is the extent of Professional development offered through the LAUSP?
Who has received LAUSP professional development?

Data Collection Instruments

We designed our data collection instruments to reflect the literature reflecting inquiry-based practices in mathematics and science classrooms (see Appendix C).We made several assumptions, based on our reading of this literature. First, inquiry-based teaching leads to

greater scientific literacy, both in content and process skills, development of critical thinking, and higher achievement on tests of procedural knowledge and the construction of mathematical knowledge. [7] Second, effective teaching strategies focus on developing students' inquiry skills. Foremost among these strategies is the use of good questioning skills. Well-developed questioning skills promote the use of higher-order cognitive skills. When teachers encourage students to describe, clarify, elaborate, analyze and justify propositions, they are able to discern what students know, what students don't know, and what lies at the source of students' conceptual misunderstanding[8].

Classroom observations were conducted over the course of three consecutive days during spring 2002. Our findings are based on classroom observation narratives, observation checklists, quality of instruction ratings, and teacher interviews.

We rated the quality of instruction using a protocol developed by researchers at UCLA's National Center for Research on Evaluation, Standards, and Student Testing (CRESST) to rate quality of instruction.[9] The protocol captures the following dimensions of instruction: quality of the lesson goals, alignment of goals and lesson activities, cognitive challenge of the lesson, and the level of student engagement. We rated each dimension on a 4-point scale.

We analyzed direct classroom narrative using a qualitative coding scheme and then averaged these findings across the three days of observation. Our observers documented teacher and student activity in each of the following categories: instructional activities,

[7] Haury, D. (1993) Teaching Science through Inquiry, Columbus OH; ERIC: ED359048
[8] Waxman & Walberg (1991) Effective Teaching: Current Research, McCutchan Publishing
[9] Clare-Matsumura, L., Pascal, J, Valdes`, R. (2001) Quality of Classroom Assignments Indicators

instructional strategies, teacher questions, student questions, degree of feedback teachers provide to students, opportunities for students to engage in discussions, opportunities for the development of literacy skills such as vocabulary, and reading and writing within these disciplines. Additionally we examined the opportunities for students to engage in self-assessment and to learn from peers, particular teaching strategies that included making material relevant to students' lives and assisting students to make connections to previous lessons, and whether teachers drew conclusions and summarized the material at the close of lessons. In addition, we collected samples of in-class assessments, worksheets and supplemental materials to further analyze the alignment of instruction and assessment.

In order to measure the extent of inquiry-based practices in the classroom, we developed an observation checklist to capture the specific characteristics of instructional strategies and student activities.

Using a modified version of Bloom's Taxonomy of Cognitive Learning, a rubric was developed to analyze the complexity of teacher questioning directed at developing students' inquiry skills. We rated teachers use and quality of questions during the lesson using a condensed 4-stage taxonomy: (1) recall; (2) making connections; (3) encouraging students to make a claim; and, (4) encouraging students to justify, critique or evaluate information. Analysts used this instrument to measure the type and frequency of questions used by teachers over the course of the three days[10] (see Appendix for questioning scale).

[10] The taxonomy provides a useful structure by which to measure questioning levels; (to simplify analysis the 6 were condensed)

We also conducted interviews with teachers and principals to identify specific conditions and challenges pertaining to teachers' implementation of Standards-based practices unique to these low performing schools. Specific issues addressed in teacher interviews were: teacher participation in professional development, use of mathematics and/or science coaches, use of Math/Science resource centers, articulation of lesson goals and objectives, teacher's use of course outlines or pacing plans, and teachers' familiarity with the Standards.

Findings

Overall findings will be presented in three sections: elementary, secondary, and professional development. The primary findings are:

Sixty percent of all elementary teachers did not conduct a single science lesson during our three-day observation period and only 15% were observed to conduct a science lesson on two or more days. By contrast, 77% of all elementary teachers taught a math lesson on all three days.

In 95% of the elementary mathematics classrooms, instruction consisted primarily of teachers presenting the material in a didactic fashion, characteristic of "traditional" classrooms.

Student activities in mathematics primarily consisted of work on computational or procedural skills, answering short "fill in the blank" type questions, and individual seatwork.

The majority of questions asked by elementary mathematics teachers required students to recall facts and seldom required students to explain their answers or develop their reasoning skills.

In elementary classrooms, science lessons were more likely than mathematics lessons to involve inquiry-based instructional strategies.

Use of technology was not prevalent in elementary, middle or high school mathematics or science classrooms.

Pass rates in secondary mathematics and science courses were low. In both the LAUSP and comparison high schools only 40% of the students passed their first year mathematics courses with a grade of C or better and close to 45% passed first year science courses.

A new district policy requiring eighth grade students to take Algebra more than doubled the number of students enrolled. Despite the large increase in students entering Algebra in the eighth grade, the pass rate declined only slightly.

In secondary mathematics and science classrooms, the tasks assigned to students were seldom aligned with the stated goals.

LAUSP workshops targeted elementary science teachers more frequently than any other teacher group.

In this first academic year, the LAUSP professional development workshops equally served both the district-at-large and the LAUSP target schools.

Seventy-five percent of high school math teachers indicated that they had no interactions with a math coach.

Elementary Classrooms

The California Content Standards identify what all students should know and be able to do in each subject and at each grade level. Decisions about how to teach the Standards are left to teachers, schools and districts. In LAUSD, elementary teachers are expected to teach according to the California Standards in all subjects including reading, mathematics and science. While this is the expectation, the district has offered far more direction and support in the areas of reading and mathematics, elevating the emphasis of these areas above other subject matters. The District Reading Plan designates roughly half of all instructional time to language arts. The District's Mathematics instructional pacing plan allocates the number of instructional days per year to cover each topic. While there is no directive to teach math daily, in order to cover the breadth of material it has been suggested that teachers use 60 minutes of each day for math instruction. All other subjects are to be taught during the remaining 90 minutes, although no districtwide plan has been established for the remaining curricular areas, particularly social studies and science. Furthermore, no standardized assessments are currently being administered for science in the elementary grades.

Quantity of Elementary Math and Science Instruction

The amount of time spent in mathematics and science in these elementary classrooms varied considerably. We found while not all teachers taught math on each of the three days observed, we found that most teachers did not teach science on any of the days observed. Moreover we found no consistency in time allocated per lesson for either mathematics or science instruction (Table 3 below).

TABLE 3: NUMBER OF ELEMENTARY TEACHERS CONDUCTING MATH OR SCIENCE INSTRUCTION WITHIN THREE DAYS OF OBSERVATION

		Math				Science			
Days		0	1	2	3	0	1	2	3
LAUSP	N	0	1	3	27	19	7	2	3
(N=31)	%	0%	3%	10%	87%	61%	23%	6%	9%
Comp	N	0	1	9	21	19	8	2	3
(N=32)	%	0%	3%	28%	65%	59%	25%	6%	9%

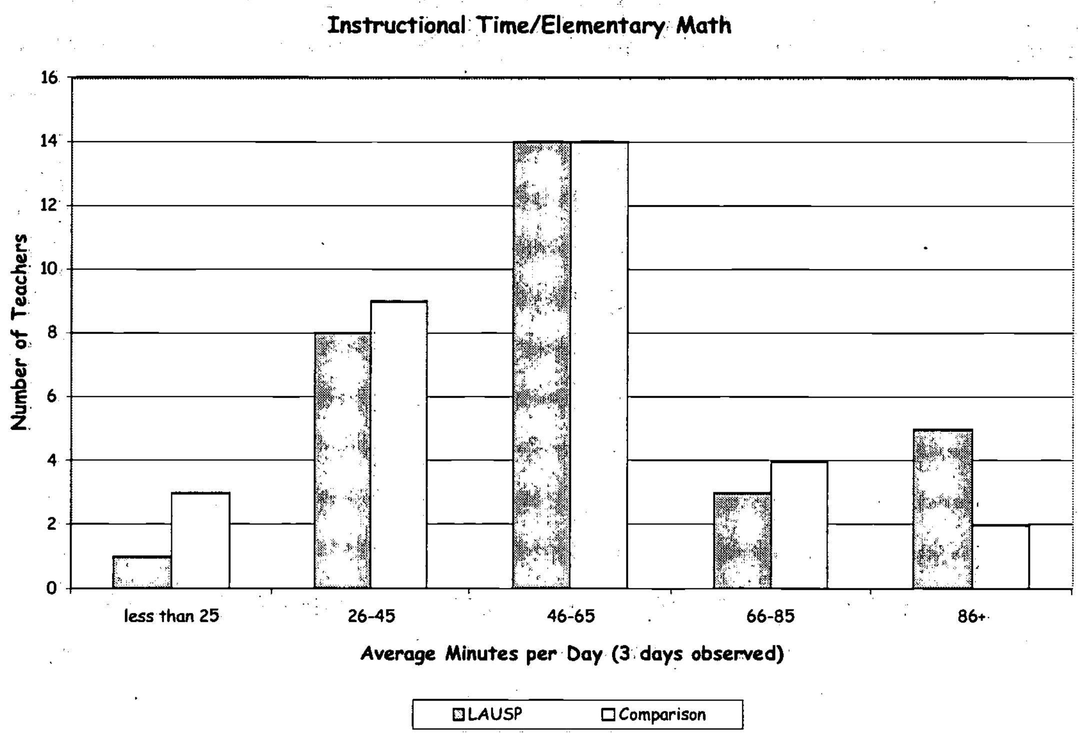
*Data from only 63 elementary teachers were available at this time.

More of the LAUSP teachers conducted math lessons on all three days observed than the comparison teachers. No differences were observed across the two groups in the number of science lessons observed.

Elementary Mathematics

We found no consistent patterns in daily instructional time devoted to mathematics. While over two-thirds of the teachers taught math everyday, the actual time devoted to math instruction on any given day observed ranged from as little as 22 minutes to a high of 114 minutes. Mathematics instructional time was averaged across the three days for each teacher and no notable differences were observed between the two groups; both groups daily instructional time averaged between 45-65 minutes (see Figure 3). We observed considerable variability within the two groups across the three days suggesting that teachers adapt the pacing plan to meet their needs.

FIGURE 3: AVERAGE TIME SPENT IN MATH INSTRUCTION



Sixty-six percent of the teachers mentioned using the pacing plan to guide their lessons; Even so, many indicated difficulties adhering to the pacing plan. In order to cover all the concepts, some teachers chose to teach more than one math lesson per day, others felt they could only cursorily cover the material before they had to move forward, and some limited their coverage to those concepts they knew would be covered on the SAT/9. As one teacher reported,

> "This is the first year of the new math program that they implemented at the school and it goes fairly quickly, but they want us to teach one lesson per day. But I've taken it apart and I usually do one lesson for two days, and if I see that they still don't grasp the concept or the algorithm then I'll spend more time on it. I'm deviating from what they told us to do."

Another teacher reported the need to devote more time to math than prescribed:

> "The pace has been established formally and informally by our school district. Formally in that we received this publication and we received some training in the publication, and were advised to do a lesson a day or more. That is not always appropriate for effective learning. So my pacing often isn't so much, can I teach one lesson as what can I shift from the rest of my day? I teach two different math lessons a day, plus a warm up. So I'm actually doing three math lessons a day. And I don't try and cram in everything to an hour and a half a day. I figure out a way to carve out extra math in the mornings to late morning and the afternoon."

More than anything else, teachers cited the lack of time as the biggest barrier to effectively implementing the mathematics curriculum. These time limitations stemmed from two opposing pressures. First, the state mandated exams and second inadequately prepared students. The state exam both created pressure to cover material and consumed valuable instructional time. Students' limited skill base and comprehension levels slowed the pace of instructional delivery or led teachers to accept the fact that some students would be left behind. One teacher remarked,

> "It's a real problem, because we are on a pacing plan. And if we don't get it all covered [the preparation for the SAT/9] then we aren't ready for the tests, and there isn't--- a lot I can do to go back and re- teach or anything like that. We just do not have the time. I would like to be able to go back and help the children who are really having difficulties, but there just isn't any time."

Other teachers felt the pacing plan doesn't consider the possibilities that students may need additional assistance in order to prepare for the SAT/9.

> "They're lacking in the most fundamental skills. I have 6 out of 29 students that were able to memorize the multiplication tables through 12. If it's a lesson where I feel that they don't get it, I'll go back and re-teach it for a day or two until I see that they understand."

> "I focus most on what the Stanford 9 requires and make that my primary focus and when I can add new things but they have to do well on that test so that is my priority."

Additionally teachers voiced frustrations that the districts' pacing plan was not appropriately aligned with the preparation required for the SAT/9. Teachers appear to readjust the plan to meet the demands of the exam.

> "I've found that it really isn't adequate for preparing the students for what they really need to know. Especially when it comes to the SAT/9 test. They leave a lot of the information that the children are supposed to be aware of for the end of the year. According to the pacing plan, things like geometry, ordinary measurement—and a few other areas that I can't think of right off the top of my head—are presented at the very end of the year. When the children take the SAT/9, it is given six to eight weeks prior to the end of the year. They will not have had a chance to learn those concepts and not really mastered them."

Elementary Science

Science instruction occurred much less frequently than mathematics instruction. Forty percent of the teachers in our study were observed conducting a science lesson. Of those teachers, only 10 taught a science lesson on two or more days. Among those teachers teaching more than one science lesson no patterns were observed detecting a plan or set time devoted to science. Lessons ranged from one minute (students watched their seeds grow) to 65 minutes (an experiment in water evaporation based on student hypotheses) with an overall average of 35 minutes per lessons for those science lessons observed (see Table 4). No differences were noted between the two groups regarding the number of teachers electing to teach a science lesson, or the number of teachers teaching more than one lesson across the three days.

TABLE 4: INSTRUCTIONAL TIME/ELEMENTARY SCIENCE

Classroom	Time Spent (min.)		
	One Day	Two Days	Three Days
		LAUSP	
1	20		
2	40		
3	30		
4	20		
5			50,30,30
6	38		
7		55,43	
8	45		
9			45,45,40
10	26		
11		22,20	
12			11,42,42
		Comparison	
13	55		
14		30,22	
15	1		
16	65		
17	15		
18			20,25,30
19	.		30,10,1
20		20,13	
21	80		
22	104		
23	35		
24			55,59,25
25	42		

In teacher interviews we asked how often they conduct a science lesson and 55% of them indicated weekly, 15% said bimonthly, 10% mentioned that they conduct a science lesson

quarterly and 20% admitted rarely or never. While these teachers acknowledged conducting science lessons with some frequency, others acknowledged that current policies prevent or confine the extent of science topics to those included in the Open Court reading curriculum. As these teachers' testimonials reveal, opportunities to conduct a science lesson are quite rare.

> "Well it's in my Open Court reading, so that's my science, but it's not that often."
> "Since I've spent so much time with the Open Court and with the math that we are compelled to teach, I've truly done [only] one science lesson this year."
> "With Open Court taking such a large part of the day, I'm lucky if I can squeeze in math and science for a half hour at the end of the day. Actually science, health, art, and music have gone by the wayside, which is unfortunate, because the kids really need it. We are a Title I school and I feel that the children need other things besides just reading and math."

It appears teachers' decision about what to teach and what materials to use are fairly random in elementary science. Teachers seem to choose topics according to their own discretion as noted here,

> "You know, our science is, well, we really haven't picked a new program that is Standards based. We have several old programs and teachers often just kind of pick and choose as far as that goes."

While teachers admittedly teach little science, they blame it on time constraints imposed by the district's math and reading initiatives. Although teachers did acknowledge attempts to incorporate science lessons during the year, there is little evidence to suggest that teachers have a curriculum to follow or use the Standards as a means to guide their curricular decisions. For example one teacher noted,

> "So, I teach Science as we go along, as something comes up. If we're reading about Benjamin Franklin, I can teach about some of his science discoveries. If we're reading about Galileo, we can talk about what Galileo discovered how did he prove that."
> This year we were actually told not to put too much emphasis on the science although we're going to go back to it next year because this was a new year for the Open Court."

In order to deal with the issues of "fitting science into the day", it appears some schools have developed alternative methods in order to include science into the elementary curriculum. As these teachers reported,

> "Science in our school is done by a science specialist. We don't have too much time to do it, so she comes in. She comes in once a semester for a six-week period three times a week."
> "We do it in blocks of weeks, so it's every other week we focus on science, and alternate it with social studies."

Teachers mentioned that science lessons "get the short shrift" or merely emerge from some external activities as part of the district adopted reading plan. While the district has placed an equal emphasis on math and reading, the comments above indicate that without a district policy regarding a science curriculum, science will be taught sporadically and randomly. The lack of state mandated testing for elementary science combined with increased pressures upon schools and administrators to raise academic performance in language arts and mathematics has limited the extent to which teachers cover the elementary science Standards.[11] It also appears that teachers determine the scope and sequence of the science curriculum based on their own prior knowledge, access to materials or personal interests. In the cases where a substantial amount of time was devoted to science, those teachers were from the school that used science specialists to

[11] SAT/9 science testing is not mandated in the elementary grades.

teach science. The above findings suggest that, absent a district policy regarding the elementary science curriculum, the delivery of a Standards based curriculum across the district will be idiosyncratic and sporadic.

Quality of Mathematics and Science Instruction in Elementary Classrooms

The quality of both mathematics and science lessons is determined by the teaching strategies employed, the level and depth of teacher and student interactions, and the opportunities afforded to students to develop disciplinary reasoning and inquiry skills. The Standards require that teachers employ instructional strategies that extend beyond merely transmitting facts and procedures to those that stimulate and support students' development of "higher-order" thinking. Reflective of the Standards, mathematics and science lessons should provide students opportunities to develop both mathematical and scientific reasoning and problem solving skills. Lessons designed to further develop these skills, require activities that use students prior knowledge and allow students opportunities to construct their knowledge through actively engaging in the lesson, opportunities to communicate their thinking and build upon the collective knowledge of their peers. According to the National Research Council (1997), teaching approaches that support inquiry are active, not passive, and include collaborative learning, small group discussions, posing questions during lecture, and inquiry-based field and lab experiences. Classrooms, therefore, should reflect the following activities: observing and exploring, experimenting and solving problems, working both as a team member and individually,

testing hypotheses and communicating findings, and making arguments and supporting them with evidence. [12]

Instructional Strategies in Elementary Math

Teaching strategies most commonly observed during mathematics instruction resembled those found in "traditional" classrooms, where the teacher conducts the classroom as a whole group, generally in the form of a lecture. In over 95% of the mathematics classrooms the lecture format was observed at least once during the three days, and among 87% of the teachers this strategy was used on two or more days observed (see Table 5).

TABLE 5: INSTRUCTIONAL STRATEGIES IN ELEMENTARY MATHEMATICS CLASSROOMS

Instructional Strategy	LAUSP (N=31)	Comparison (N=31)
Traditional		
Teacher leads whole class	97%	97%
Lectures/presents a lesson	94%	78%
Circulates to provide assistance and feedback	90%	81%
Checks for prior learning	84%	81%
Inquiry-Based		
Leads a discussion	42%	58%
Asks for students to clarify, justify and explain answers	58%	61%
Summarizes main points at the end of activity	42%	45%
Asks open-ended questions	45%	48%
Categorizes information, compares, and contrasts	35%	35%
Proposes to students to conduct a study/research question	19%	6%

Teaching strategies known to be more reflective of inquiry-based instruction were observed far less frequently than "traditional" strategies. We observed an inverse relationship between the percentage of teachers utilizing a strategy and the degree that the strategy could be characterized as inquiry-based. The most frequently observed inquiry-

12 Flick, L (1995) Complex Instruction in Complex Classrooms: A synthesis of research on inquiry teaching methods. Paper presentation National Association for Research in Science Teaching, S.F

based instructional strategy was the practice of checking for prior learning, with nearly 80% of the elementary teachers observed using it on at least one of the days. Roughly 60% of the teachers asked students to clarify and explain their answers at least once during the three days. The least frequently observed practice in mathematics classrooms was conducting a research study or exploring a "real-world" question, with only 10% of all teachers utilizing this strategy in their classroom.

While nearly half of the elementary teachers were observed to ask their students open-ended questions, upon closer examination of the classroom narrative, the majority of teachers' questions focused primarily on asking students to recall basic information. Teachers' questions did not routinely require students to explain their answers or provide evidence to support their statement. Teacher questions were analyzed using the scoring rubric derived from Bloom's taxonomy (see Appendix B). The vast majority of questions were categorized as basic recall for both LAUSP teachers (81%) and the comparison teachers (61%).

The following provides an example of the typical discourse and instructional activity most frequently observed in mathematics classrooms.

> Teacher tells students she will review one or two problems then they will work alone quietly.
> T: What are we going to do?
> S: Fractions
> They read instructions from the book together and then T draws 1/3 on the board.
> T: One out of 3 is shaded so, all the boxes go on the bottom, the shaded one goes on the top.
> T: Ok, how do you say this? (Teacher writes problem on board)
> S: 2 out of 4
> T: How else can we say it?
> S: 4 out of 2
> T: No, two fourths.

Teacher gives them 6 minutes to finish review and circulates and helps a few students and then asks the students to put their heads down when finished. Teacher calls time up and tells students its time to check their work.
T: What's the answer?
S: 2/3
T: How do you write 2/3?
Teacher writes these fractions on the board: 2/3, 5/6, 1/2
T: Right, but we say one half."
T: Seventeen take away eight is what?
S: Nine
Teacher reads each problem. Students recite answers. Teacher reads instructions on next page.
T: They gave you 1/2 and 1/3, which one is less boys or girls?
S: 1/3
Teacher circles 1/3 and says "You have 3 minutes, go." and the teacher circulates.
T: (Addressing a student) Look, this is the one's place, cross that out.
S: Ms., do you have to borrow?
T : No look at the one's place.
T: Where are my quick followers, I know its almost lunch but we have to get through this for the SAT 9.
Teacher reads from the textbook. "They say 5 out of 6 is greater than 2 out of 6 is that true?"
S: True
Teacher writes 5/6 > 2/6 on the board and dismisses the class for lunch.

The discourse illustrates a typical lesson in which the teacher exposes students to facts and routine procedures and provides answers to her own questions rather than aiding students' understanding. Literature on "effective" teaching suggests that teachers should provide students with activities that allow them to be physically and mentally involved in the subject matter, ask questions that stimulate thinking, probe students for responses asking for clarification and elaboration, use concrete examples related to students' lives and conclude lessons by highlighting the main points to reinforce the link between prior and new knowledge.[13] The questioning observed in the classroom did not mirror this image, as the questions teachers posed above were those asking for recall of information and verification of procedures previously learned.

[13] Tobin, K. & Fraser, B. (1991) Learning from Exemplary Teachers, Effective Teaching; Berkeley

The instructional practices observed in these elementary classrooms reflects a more traditional pedagogy, with less than 50% of the LAUSP teachers and less than 60% of the comparison teachers observed to conduct a discussion with their students. Discussions of any length (more than 8 minutes) were not prevalent in the elementary mathematics classrooms we observed. In most classrooms neither the teacher nor the student were asked substantive questions. In those instances where teachers would pose open-ended questions to assist students to make connections, observers noted that teachers' frequently answered their own questions. When teachers' posed questions, they primarily focused on explaining particular procedures as opposed to exploring student understanding and misunderstandings. When discussion occurred, it was often after a teacher lectured on a topic and then directed students to share with a partner or recall the list of facts recently learned about a topic.

Without sufficient conversations and opportunities for students to explain what they do and don't know, it becomes difficult for the teacher to assist students to make sense of what they are doing in math and to further assist them in developing mathematical thinking. While the examples of such practice were rare, we did find examples where teachers asked students to demonstrate their reasoning or explain their grasp of the material. Teachers using these inquiry strategies with their students served to both assist students' comprehension of the material and ensure that teachers understand what students know. In the following example, the teacher challenges the students to explain how they arrived at a particular conclusion.

"You are both right, I can't do it for subtraction, so where do I get more? - Don't just guess number 7, I want to see some work as to how you figured it out. Draw a picture or use words. -You have to be able to explain it to me or to someone else, so I know you really understand it."

Although 80% of teachers indicated they use the tests administered in class to determine whether students have learned the content of the lesson, some teachers offered these inquiry-based strategies for assisting student understanding.

"If they can explain it back to me in a way other than the examples that we have used. And probably the most solid method I use is when they can explain the problem or a class example to another child."

"I'm always asking them why they chose that answer, or asking them to give reasons for that answer to make sure. That's one of the best ways I know whether they really understood it. And that helps me know what more I have to do and what other methods I could use to bring the lesson to them."

Student Activities in Elementary Math Instruction

The California Mathematics Content Standards state that students should develop not only a fluency in basic computational skills, but also an understanding of mathematical concepts. Students should be able to reason mathematically and scientifically by gathering data, analyzing evidence, and building arguments to support or refute a particular hypothesis thereby enhancing their abilities to use evidence to justify their answers. The activities most frequently observed in elementary mathematics classrooms were not those reflective of inquiry skills but rather those resembling "traditional" classrooms with students working primarily on computational or procedural skills, answering short one-answer questions, working individually rather than with partners or in small groups (see Table 6).

TABLE 6: STUDENT ACTIVITIES IN ELEMENTARY MATHEMATICS CLASSROOMS

Student Activity	LAUSP (N=31)	Comparison (N=31)
Traditional		
Computational or procedural skills	87%	84%
Applied use of new vocabulary	55%	52%
Answering short one answer questions	90%	80%
Working individually	96%	74%
Worksheet	71%	65%
Inquiry-Based		
Evidence of signs, symbols, models or graphs	65%	45%
Asked to communicate reasoning, justify or explain	54%	52%
Applying skills to "real world" applications	58%	26%
Opportunity for hands-on learning	58%	42%
Asked to investigate/solve a problem, make a hypothesis	36%	35%
Collecting or recording data	29%	23%

Student activity in mathematics typically involved students working on computational or procedural skills, individually, at their desks, using worksheets or solving problems from the textbook or the blackboard. While the majority of teachers conducted a lecture to introduce the class to a particular topic, for some portion of the remaining lesson, students were engaged in the following activities: solving problems from the textbook, solving problems from the textbook using manipulatives, or taking quizzes in the form of worksheets.

While traditional activities were found in nearly every classroom, in a majority of LAUSP classrooms and a large minority of comparison classrooms, students also engaged in inquiry-based activities. In the majority of classrooms, students were asked to communicate reasoning or explain their answers at least once during the observation period. Using journals, a strategy often used for this purpose in mathematics and science classrooms to assist and further develop students' inquiry and literacy skills, was adopted

by 13% of the teachers as a means to record their mathematical understanding or catalogue the skills they learned.

Even in the first year of implementation of the LAUSP, more of the LAUSP elementary teachers engaged students in inquiry-based activities than their counterparts in the comparison schools. On three characteristics of instruction the differences were noteworthy. Far more LAUSP teachers (forty percent more than comparison teachers) provided students with lessons using representation or models of mathematical concepts to concretize more abstract ideas (*the use of signs, symbols, models or graphs*), "hands- on" learning opportunities, and application of concepts to "real world" contexts.

As for the materials used in the classroom, the majority of teachers used the chalkboard, the textbook, and worksheets to engage the students with the content of the lesson. Twice as many LAUSP teachers were using manipulatives in their classrooms compared to the comparison teachers (see Table 7).

TABLE 7: USE OF MATERIALS IN ELEMENTARY MATHEMATICS CLASSROOMS

Materials Used*	LAUSP (n=32)		Comparison (n=32)	
	(at all)	(2 or more)	(at all)	(2 or more)
Chalkboard	19	13	22	19
Overhead Projector	12	5	10	5
Textbook	17	11	23	19
Handout/Worksheet	19	9	15	4
Math Manipulatives	15	5	8	5

*The above data is drawn only from those observations that included this information.

While the majority of teachers observed practiced traditional pedagogy in their mathematics lessons, those that engaged in inquiry-based practices found them particularly useful to assist students in their understanding of abstract mathematical concepts. As the following teachers confirmed in interviews manipulatives were valuable instruments for both the students' comprehension and the teachers' understanding of what concepts are challenging to students.

> "I discovered if they have a manipulative, they're more likely to understand the concept."
> "When they're using the manipulatives and I can tell whether they have grasped the concept or not."

Students use of technology, (computers or calculators) was not found in these classrooms and thus not included in the table of materials used in these classrooms below.

Even though more inquiry based practices were observed among the LAUSP teachers, opportunities for students to collect or record data or opportunities for students to explore or solve a real world problem were only observed to occur in fewer than 36% of the classrooms in either group.

> "In traditional classrooms, it is teachers who are active, they convey facts and inculcate knowledge. Students are passive receptors of this knowledge. These classrooms typically consist of teachers presenting the "right" way to solve problems (or even the "right" solution). Knowledge in this situation is isolated; learning does not typically motivate students or provide them with problem-solving skills they can apply to other situations."
> (Dewey, J. (1902) The Child and the Curriculum. Chicago; The University of Chicago Press.)

Dewey's portrait of traditional classrooms, expressed over a century ago, continues to depict the majority of instructional practices we observed. While more of the LAUSP teachers are employing inquiry skills in their lessons compared to their counterparts, there

are very few instances of actual discussion and instructional conversations about the subject matter. Opportunities for students to engage in conversations and respond to open-ended questions were not occurring. The instructional strategies used by teachers and the instructional activities or opportunities afforded to students reflect the enduring conceptions of knowledge that Dewey sought to change.

The pressures and constraints of teaching in an urban environment appear to reinforce the use of traditional teaching practices. Typical practice emphasizes computation, directs student activity toward answering textbook/worksheet problems, and measures performance via weekly tests. Conceptual understanding, if a goal at all, appears to have been crowded out by low expectations (teachers within this study have alluded to the difficulties in creating more "effective learning environments"), inadequate preparation, and/or language facility.

Furthermore, the state accountability system places high value on standardized tests, which frequently emphasize algorithm over understanding, content coverage over mastery, and test preparation over authentic performance. Conceivably, students schooled in a conceptually rich, inquiry-based method would learn less content, but learn it well enough to compensate for the lack of coverage, and thereby perform equally well or better on standardized tests. More importantly, the learning accomplishments would then reflect what it means to be a mathematician or scientist, rather than a student of isolated facts.

Instructional Strategies in Elementary Science Classrooms

Perhaps the most significant finding in elementary science classrooms is that only 40% of the teachers were observed conducting a science lesson. Of these, all employed the instructional strategy of teacher-led whole class primarily devoted to lecture (see Table 8).

TABLE 8: ELEMENTARY SCIENCE TEACHERS' INSTRUCTIONAL STRATEGIES

Instructional Strategy	LAUSP (N=9)	Comparison (N=11)
Traditional		
Teacher leads whole class	100%	100%
Lectures/presents a lesson	89%	64%
Circulates to provide assistance and feedback	44%	46%
Checks for prior learning	77%	55%
Inquiry-Based		
Leads a discussion	55%	82%
Asks for students to clarify, justify and explain answers	33%	27%
Summarizes main points at the end of activity	11%	9%
Asks open-ended questions	66%	73%
Categorizes information, compares and contrasts	33%	55%
Proposes to students to conduct a study/research question	33%	36%

In conducting their classrooms, both sets of teachers used whole class and lecture format. Lectures were more prominent in LAUSP classrooms (89% v. 64%), while the comparison teachers made more frequent use of classroom discussions (82% v. 55%). The comparison teachers employed more of the other inquiry strategies as well, such as using compare and contrast (55% v. 33%).

Overall, science teachers made greater attempts to engage students in discussions than did mathematics teachers. This is supported by the relatively high percentage of teachers asking open-ended students questions (about 70% overall). While more discussion and

question asking is encouraging, still, only one-third of the teachers asked students to clarify or justify their answers.

When questioned, teachers freely admitted that the Standards play only a minor role in determining the science content taught. Given the lack of a strong district emphasis on elementary science, we were not surprised to find that teachers did not fully implement the state science standards. Teachers were not embarrassed by their lack of awareness of the Standards. Teachers noted,

> "Most teachers unfortunately, are moved from grade to grade every year. You, know, one year they're first grade, the next they're fifth, and you never really get quite comfortable and you don't learn the Standards."

> "I know we have some, I couldn't tell you exactly what they are. I know the basic area they are in but that's about it."

> "I am completely unfamiliar, and we haven't even looked at them this year!"

Without a district emphasis on science instruction, teachers' science curriculum typically reflects familiarity with a topic or the availability of a prepackaged kit inclusive of all necessary materials and instructions. Teachers claim that this is all they can do, for so doing consumes what little is left of their available time and resources. Many of their colleagues are not even providing this much science instruction; 30% of all elementary teachers admit to conducting science lessons fewer than four times per year.

Student Activities in Elementary Science Instruction

In elementary science classrooms, the student activities demonstrate an even balance of traditional and inquiry-based characteristics. The most prominent activities observed were

those that had students making observations, answering short one-answer questions and using newly learned vocabulary. Student activities were essentially the same in both LAUSP and comparison classrooms (see Table 9).

TABLE 9: STUDENT ACTIVITIES IN ELEMENTARY SCIENCE CLASSROOMS

Student Activity	LAUSP (N=9)	Comparison (N=11)
Traditional		
Computational or procedural skills	11%	9%
Applied use of new vocabulary	66%	64%
Answering short one answer questions	66%	64%
Working individually	44%	35%
Worksheet	11%	45%
Inquiry-Based		
Evidence of signs, symbols, models or graphs	22%	18%
Making observations	66%	72%
Collecting or recording data	33%	54%
Asked to communicate reasoning, justify or explain	33%	54%
Opportunities for hands on learning	44%	45%
Asked to investigate/solve a problem, make a hypothesis	33%	45%
Applying skills to "real world" applications	33%	27%

We observed a positive relationship between the frequency of teachers employing strategies characteristic of inquiry-based instruction and the percentage of lessons with "hands-on" opportunities in science classrooms. "Hands-on" science is defined as any science lab activity that allows students to handle, manipulate or observe a scientific process. "Hands-on" science is well supported in the literature. According to Loucks-Horsley et al, (1990) "exemplary science instruction is promoted by both hands-on and minds-on instructional techniques, those foundations of constructivist learning." [14] Fifty percent of the elementary teachers we observed conducted lessons using a "hands-on" component in their lessons. Among the handful of teachers conducting more than one

[14] Loucks-Horsley, et. al. (1990) Elementary School Science, Association for Supervision and Curriculum Development. Alexandria, VA/Andover, MA

science lesson, "hands-on" activities were observed on each occasion. The opportunity to conduct an experiment or observe a phenomenon was the most prevalent "hands-on" instructional activity observed, and in quite of few of those instances, students also collected and recorded data. The following example illustrates how a teacher successfully incorporated a "hands-on" lesson with the advancement of students' inquiry and literacy skills.

> After the teacher introduces the science lesson through a song, she begins the lesson with a discussion about bees. She holds up a handmade bee and calls the students to see if they know why bees are so important to our environment.
> Students respond: Because they make honey.
> S: They pollinate
> The teacher lectures about bees getting nectar from the flowers. Students say they have already done labs on pollination. They make connections to pollination that they have learned. Students listen attentively. Teacher shows them a flower from their school garden. She makes the connection about what the bees role in pollination is. Students talk about the bees helping pollinate flowers, and how they bring the pollen to the flowers and back to the hive to make honey. Teacher talks about when and why bees sting. She passes out a book to the students and has them read more about bees. Student tells them about bee stings and why a bee might sting you and most importantly what to do if you get stung. She walks around handing out a mixture of baking soda and water to demonstrate what to do if you get stung. She asks them to keep an eye on what happens to the solution on their arms as they read about bees.
> T: When you think of bees, you must think of flowers. We are looking for that today. See that take a good look at that picture because that's what you will be looking at today.
> T: You need to bring your lab books outside with you because here are the questions that I want you to think about as you go outside. Now before you do that, who can take a look at their arms and describe to me that change that took place to the medicine that I put on your arms.
> S: It turned cracky and the water dried.

[15] Loucks-Horsley, et. al. (1990) Elementary School Science, Association for Supervision and Curriculum Development. Alexandria, VA/Andover, MA

T: So we are going to go outside and discover some things about honeybees. So let's write down our discovery questions that we are going to try and answer as we go on our honey bee hunt.

(T sends them on their way outside as soon as they have finished writing down their questions.)

S: Let's do a test and see if we can count how many bees go to the purple flowers and how many bees go to the yellow. Let's see which color flower they like the most.

S: It has pollen all over its legs.

S: I see its red . . .

T: Which flowers do you think the bees like the most out here. . . go and discover and see it with your eyes. . . . . you have 3 more minutes to study flowers and bees before we start our report.

They return to the classroom. Teacher passes out examples of reports students have done from the other class. "Now I'd like to recommend 3 things: 1. You must draw a flower with the honey . . . on it. 2. You've got to draw a bee going into a flower. 3. You must draw a picture of the bee with the honey on its legs. . . Now feel free to refer to these reports, but you can also use the little book we read on page 8 and 9. "

S: We found a lot of bees. Most of them had black stripes. We saw 11 flowers with guides. And most of the bees had a lot of pollen. We saw 12 bees eating nectar. Most of the flowers don't have guides. And bees are covered in fur or hair.

T tells students, "very nice work, now show me how you would illustrate what you just wrote."

Students are recording their findings. Teacher circulates to provide feedback about what they wrote and drew: "I don't read anything here about how the bee brings the pollen back to the hive. Maybe you could tell me a little about that, and then draw a picture of it."

Most of the students decided to illustrate before writing. Teacher circulates some more. She has taken out their preserved bee collection to show the students that have finished their journal entries.

Most students wrote one simple sentence in their journals: "Today I saw and learned a lot about bees and flowers."

Teacher dismisses the kids looking at the bee collection back to their seats and instructs them: I want you to write one thing from the book in your journals, something that you think was interesting. I want you to write about it in your journal.

In this lesson, the teacher successfully incorporates a variety of instructional strategies and student activities within the lesson and includes a reflective component at the end of the lesson to assist students to make the connections between prior and newly gained knowledge. The above example also illustrates how teachers can incorporate science topics to address students' development of language arts outside the context of a prescribed reading program. While the above example was unique in our sample, it provides a glimpse or model for teachers to explore how to successfully integrate both traditional and inquiry-based practices into the classroom.

The lesson illustrated above, administered by a science specialist and not the regularly assigned classroom teacher, illustrates how teachers can incorporate collecting and recording data into a science lesson and use science journals as a means to assist students to express their understanding, record reflections or ask questions. In schools where a science specialist was present, more teachers were observed to regularly engage their students in science.

In science, as compared to mathematics, a greater degree of inquiry-based practices were observed. We noted more discussions, more open-ended questions, and more labs and observations. These had the cumulative effect of affording students more opportunities to engage actively with science topics. Conversely, science lessons did not occur in any predictable pattern, indicating a lack of direction by the district, resulting in confusion on the part of teachers as to what is expected of them regarding a science curriculum. In as much as teachers are able to include science at all, the majority use the occasional unit included in the reading program as their curriculum. While the lessons may be more

engaging and inquiry-based than mathematics lessons, there is little evidence to suggest that teachers are teaching according to the California content Standards. It is interesting to note that in those science classrooms where inquiry strategies were employed, those same teachers did not employ inquiry-based teaching strategies in their math lessons.

Until the district places greater emphasis on elementary science, the expectation that teachers will teach science according to the Standards may be unrealistic. A more concentrated study of elementary schools using science specialists may be worth exploring as teachers in those schools seem to effectively integrate both traditional and inquiry-based practices in their lessons. A possible outcome of this study would be a better understanding of the usefulness of specialists/coaches and a recommendation to increase or decrease their numbers. Additionally, there may be a need to increase or specify an allotted time for science instruction in order to address teachers concerns of coverage of the material and Standards in both subject areas.

Secondary Mathematics and Science Classrooms

LAUSD graduation requirements state that students should complete two years of college preparatory mathematics and science. The University of California (UC) and California State University (CSU) systems require prospective students to complete three years of college preparatory mathematics and two year years of laboratory science with a passing grade of C or better. UC eligibility requirements further stipulate that at least 20% of these science courses must involve inquiry, observation, analysis and write-ups, and "hands-on" activities.

Quantity of Math and Science Instruction in Secondary Schools

We use two outcome measures to determine the quantity of mathematics and science instruction: 1) the percentage of students passing and completing the courses required for high school graduation, and; 2) the percentage of students meeting University of California (UC) and the California State University (CSU) math/science eligibility requirements. We added a third measure, the percentage of students completing Algebra I by the eighth grade, because of its importance both in terms of district policy and the fact that Algebra I is widely considered to be a "gatekeeper" course. Students who pass Algebra I early in their secondary schooling are much more likely to attend a four year institution following high school graduation.

Districtwide, 43% of high school students passed their first year mathematics course. Those figures are even lower among the districts low-performing schools (the LAUSP and comparison schools). This low pass rate improves only slightly as students continue

their mathematics training—one-half of the students who successfully completed their first year course passed their second year mathematics course. The pass rates for science are about ten percent higher than in mathematics, although the performance gap between the district at-large and its low-performing schools is wider for science than for math (see Table 10).

TABLE 10: HIGH SCHOOL COURSE COMPLETION RATES IN MATHEMATICS AND SCIENCE

year	Total enrolled	% passed C or better	Total enrolled	% passed C or better	Total enrolled	% passed C or better
Math - By Year	District		LAUSP		Comparison	
1st	70,580	43%	19,786	40%	16,925	41%
2nd	67,122	52%	16,324	51%	13,868	46%
3rd or 4th	67,230	64%	13,714	57%	12,298	59%
Science - By Year	District		LAUSP		Comparison	
1st	112,785	54%	32,098	46%	20,767	47%
2nd	56,710	63%	14,617	57%	9,263	57%
3rd or 4th	37,967	66%	7,510	62%	6,451	57%

We also looked at the data according to student ethnicities in order to identify differences in achievement levels. For mathematics courses, the pass rate for Asian and White

TABLE 11: HIGH SCHOOL MATH AND SCIENCE COURSE COMPLETION RATES BY ETHNICITY

	Math Year 1			Math Year 2			Math Year 3 or 4		
	lausd	lausp	comp.	lausd	lausp	comp.	lausd	lausp	comp.
Am. In.				51%					
Asian	66%	60%	67%	71%	69%	68%	77%	77%	78%
Black	41%	40%	34%	48%	47%	37%	57%	50%	47%
Hispanic	40%	39%	40%	47%	50%	44%	57%	56%	54%
White	56%	55%	52%	65%	58%	60%	78%	74%	78%
Total	43%	40%	41%	52%	51%	46%	64%	57%	59%
	Science Year 1			Science year 2			Science year 3		
	lausd	lausp	comp.	lausd	lausp	comp.	lausd	lausp	comp.
Am. In.	54%								
Asian	78%	67%	72%	80%	78%	74%	84%	83%	76%
Black	49%	45%	48%	58%	58%	58%	66%	67%	57%
Hispanic	49%	45%	45%	57%	55%	54%	60%	60%	54%
White	75%	65%	64%	79%	74%	71%	81%	81%	76%
Total	54%	46%	47%	62%	57%	57%	66%	62%	57%

* Ethnicities with a total N less than 200 were not included

students exceeds that for Black and Hispanic students by roughly 20% (see Table 11). In science, the gap is even wider. The pass rate for Asian and White students hovers around 80%, whereas Black and Hispanic students' pass rate is about 50% for year one courses, 58% for year two courses, and 60-66% for year three science courses. In both subjects, and across all years, Black and Hispanic LAUSP students perform at or above the levels of their peers in the comparison schools[16].

The District Math Plan mandated algebra[17] for all 8th grade students in 2001-2002. This policy resulted in a big jump in eighth grade student enrollment. The numbers of students taking algebra in 2002 increased by more than 27,500 students, more than doubling the prior years' enrollment (see Table 12). Opponents of this policy predicted widespread failure for these 27,500 students, who they had claimed, "were not ready for algebra." This did not occur. The pass rate declined slightly from 64% to 61%, but this is overshadowed by the fact that more students *passed* algebra in 2002 than *took* algebra in 2001. As with the senior high data, higher proportions of Asian and white students passed algebra than did their Black and Hispanic counterparts.

TABLE 12: EIGHTH GRADE ALGEBRA ENROLLMENT AND PASS RATES (WITH A C OR BETTER)

	LAUSD				LAUSP				Comparison			
	Enrolled 2001	% pass	Enrolled 2002	% pass	Enrolled 2001	% pass	Enrolled 2002	% pass	Enrolled 2001	% of pass	Enrolled 2002	% pass
Amer. Indian	73	48%	136	58%	24	37%	24	33%	3	50%	20	75%
Asian	1932	83%	3102	81%	129	85%	205	74%	171	88%	252	79%
Black	2724	56%	6492	51%	991	46%	2152	51%	335	54%	1058	48%
Hispanic	13308	60%	33587	58%	4243	59%	10279	57%	2793	65%	6054	57%
White	2259	77%	4613	75%	102	62%	192	69%	203	70%	237	65%
Total	20296	64%	47930	61%	5489	57%	12852	56%	3506	66%	7621	57%

[16] The lone exception is for Black students in first year science courses, where the pass rate for comparison schools is 3% higher than for LAUSP schools.
[17] Students could opt for Algebra I as a one or two year course of study.

Quality of Math and Science Instruction in Secondary Classrooms

The shift from traditional, teacher-directed lessons toward inquiry-based lessons requires new practices, specifically those that encourage students to actively engage in the construction of mathematical and scientific knowledge. [18] In secondary math and science classroom we used the CRESST observation protocol to capture four dimensions of instruction: the clarity of the lesson goals, the alignment of goals with lesson activities, the cognitive challenge of the lesson (levels of thinking required of the student to complete a particular task), and the level of student engagement. The dimensions of quality are defined below.

Clarity refers to how clearly the teacher articulates the specific skills, concepts or content knowledge students are to gain from the forthcoming lesson. Teachers were rated on the degree to which they focused their articulation specifically on the skills student will learn or hone.

Alignment refers to the degree to which teachers' stated goals at the outset are reflected in the tasks assigned to students. Teachers were rated on the degree to which the task adheres to the stated goals.

Challenge refers to the level of thinking required of the students to complete the task. Teachers were rated on the degree to which students were provided opportunities to engage in higher order reasoning skills as they engaged with the material.

Overall, the activities assigned to students were not well aligned with the goals of the lessons (average alignment was scored at 2 or below—see Table 13). These ratings are

[18] Richards, J. (1991) Mathematical Discussions. Radical Constructivism in Mathematics Education Dordrecht:Kluwer

consistent with our observations of other aspects of instructional strategies and student activities. These scores indicate low levels of inquiry-based practices across our sample classrooms. As we saw with elementary mathematics, student activity typically consisted of solving basic computational problems or filling in blanks on worksheets and in textbooks. We did not observe students engaged in 'real world' problem-solving activities, or other activities designed to develop students' inquiry skills. The majority of questions teachers asked students were those requiring information recall. Students spent the majority of

TABLE 13: SECONDARY TEACHERS' QUALITY OF INSTRUCTION SCORES

Subject	School level	Clarity	Alignment	Challenge
LAUSP				
Math	Middle	1.89	2.00	2.09
	High	1.59	1.59	2.02
Science	Middle	2.07	2.20	1.75
	High	2.14	2.25	2.00
COMPARISON				
Math	Middle	1.74	1.71	1.83
	High	2.17	2.08	2.00
Science	Middle	2.33	2.27	2.06
	High	2.33	2.25	2.00

(Rating is based on a 4-point scale (1= poor to 4=excellent, see Appendix)

class time listening to a teacher lecturing or working individually at their desks. We saw few instances where teachers offered students opportunities to use reasoning and explain answers rather than merely providing right answers to questions from the texts; when we did we ranked these classrooms somewhat higher.

Secondary science classrooms teachers' goals were more focused on student learning than those of secondary mathematics teachers. The teacher's stated goals also exhibited better, though still modest, alignment with the assigned tasks. Science and math teachers had similarly low levels of cognitive challenge within their lessons, as most instructional conversations/discussions consisted of close-ended/short answer questions.

Instructional Strategies in Secondary Mathematics Classrooms

Teachers' primary instructional strategies consisted of whole class instruction, typically in the form of lecture. Teachers in 64% of the high school math classrooms and 58% of the middle school classrooms lectured to students on at least two of the three days observed (see Table 14).

TABLE 14: INSTRUCTIONAL STRATEGIES IN SECONDARY MATHEMATICS CLASSROOMS

	LAUSP		Comparison	
Instructional Strategy	Middle (N=25)	High (N=20)	Middle (N=13)	High (N=8)
Traditional				
Teacher leads whole class	100%	95%	92%	100%
Lectures/presents a lesson	96%	95%	92%	100%
Circulates to provide assistance and feedback	92%	85%	77%	75%
Checks for prior learning	56%	55%	54%	88%
Inquiry-Based				
Leads a discussion	60%	35%	54%	38%
Asks for students to clarify, justify and explain answers	44%	45%	46%	25%
Summarizes main points at the end of activity	36%	30%	46%	38%
Asks open-ended questions	20%	35%	39%	50%
Categorizes information, compares, and contrasts	32%	30%	15%	13%
Proposes to students to conduct a study/research question	20%	10%	8%	0%

Secondary mathematics teachers most often employed traditional instructional strategies. While nearly all teachers lectured during some portion of the class, 25% of the middle

school teachers lectured for more than 70% of the class time and 17% of the high school math teachers spent more than 80% of class time lecturing.

The typical 50-minute lesson consisted of two types of instructional strategies: 1) a 5-25 minute warm-up activity (in which the teacher writes problems on the board or an overhead, and students solve them) and 2) 25-45 minutes of problem-solving, where students worked independently at their desks. This activity pattern contradicts research findings that growth in mathematical understanding occurs when students have opportunities to communicate their thinking and learn to explain and justify their thinking to others.[19]

Fewer than 40% of the high school mathematics teachers (slightly more for middle school teachers) conducted discussions in classrooms. Even where discussion occurred, they did not typically require students to evaluate information, draw conclusions, and employ any "higher-level thinking." Instead, we observed discussions where teachers mainly posed "closed-ended" short answer questions to the class. We did not observe a single discussion where students made contributions, formulated relevant questions, and teachers encouraged students to engage in a rich, discipline-specific conversation. Students' contributions were typically limited to asking clarifying questions regarding instructions, or to verify correct answers.

Ninety percent of the middle school and 86% of the high school teachers' questions required either a short one-answer response or basic recall of material recently presented.

[19] Vygotskly, L. S. (1994) Thought and Language. Cambride, MA: MIT Press

Ten percent of high school teachers asked no questions. Only very few secondary teachers' questions asked students to make connections and clarify their own thinking (4% and 8%, respectively).

The following example from a middle school classroom illustrates the typical pattern of discourse observed in mathematics classrooms:

> T: And what place is on the other side of the decimal?
> S: Ones.
> T: What place is this number in? -(T writes .5 on the board)
> S: 10ths
> T: How do you reduce the fraction?
> S: Divide the top and bottom by 2.
> T: The 5 is in what place?
> S: 100ths
> T: How can you tell if it's divisible by 5?
> S: If the last number is a 5 or 0.
> T: What number goes into even numbers?
> S: 2
> T: Is it in lowest terms now?
> S: No

The dialogue above exemplifies the portrait observed in secondary mathematics classrooms of drilling students to recall knowledge on basic or newly learned procedures. This example also illustrates how individual student errors can go undetected when the teacher is not skilled in the management of whole class discussions. In these classrooms, the conversation/discussion consists primarily of recitation or recall of newly learned information and places a low cognitive demand upon the student. Teacher questions merely assist students to clarify procedures and rarely lead to furthering their mathematical understandings. Students' questions, if they occurred, were generally those confirming correct procedures. Students did not have opportunities to discuss their understanding of the material with their teacher or with their peers. Listening to a teacher lecture and solving problems from the textbook are not sufficient nor will they assist students to gain

the depth of mathematical knowledge and reasoning implicit in the Standards. Students need to have opportunities to progress from concrete to abstract ideas, test their hypotheses and apply their skills to a variety of problem solving efforts.

Generally speaking, most secondary mathematics classrooms, regardless of the school level, resembled one another.[20] Fewer than 50% of the teachers asked students to provide reasoning for their thinking or encouraged students to go beyond rote learning of facts and procedures, and even fewer required students to justify their answers.

While there is nothing inherently wrong with whole class instruction or lecture, when it consumes the majority of the class period and inhibits opportunities for students to engage in conversations about the subject matter, it limits the time available for teachers to test and develop students' conceptual understanding. Engaging students in continuous drills may advance students' computational skills, yet in the absence of conversations rich in mathematics content, those activities may not further advance students' development of mathematical understanding.

Student Activities in Secondary Mathematics Classrooms

In addition to examining the teachers' instructional strategies, we examined the specific activities teachers assigned to students. These data (see Table 15) reveal that teachers place a heavy emphasis on students working individually and on practicing and drilling students on computational problems, and that teachers place far less emphasis on providing

[20] These findings are consistent with the Third International Mathematics and Science study (TIMSS) which examined typical practice across American mathematics and science classrooms, and found little variation in pedagogy and student activities consisting of primarily tasks involving drill and procedural skills. Stigler, J. and Hiebert, J. (1997) An Overview of the TIMSS Video Study, Phi Delta Kappan.

opportunities for students to communicate about mathematics and develop understandings of its use and application in the "real world." Nearly 90% of all secondary mathematics teachers, at least once during the observation, assigned students "seatwork", individual tasks characterized by low-level computational or procedural demands. Students worked on solving computational problems from the textbook or assigned worksheets on two or more days in 64% of senior high classrooms, and in 70% of the middle school classrooms.

We found evidence of the *use of signs, symbols, models and graphs* (using mathematical terminology) in over 70% of the comparison classrooms and in fewer than 60% of the LAUSP classrooms.

TABLE 15: STUDENT ACTIVITIES IN SECONDARY MATHEMATICS CLASSROOMS

	LAUSP		Comparison	
Student Activity	Middle (N=25)	High (N=20)	Middle (N=13)	High (N=8)
Traditional				
Computational or procedural skills	92%	90%	92%	100%
Applied use of new vocabulary	32%	20%	31%	50%
Answering short one answer questions	76%	85%	92%	63%
Working individually	88%	70%	92%	88%
Worksheet	52%	50%	45%	50%
Inquiry-Based				
Evidence of signs, symbols, models or graphs	56%	60%	69%	75%
Asked to communicate reasoning, justify or explain	36%	50%	62%	50%
Applying skills to "real world" applications	36%	5%	8%	50%
Opportunity for hands-on learning	32%	15%	15%	25%
Asked to investigate/solve a problem, make a hypothesis	28%	65%	39%	50%
Collecting or recording data	8%	5%	0%	13%

Students' conversations with the teacher consisted of answering short one-word answer questions. Opportunities for students to strengthen their ability to communicate

mathematical ideas or use reasoning to explain or justify answers occurred on one of three days for half of the high school classrooms and even fewer middle school classrooms.

Although infrequently observed, opportunities for "hands-on" learning were more prevalent in LAUSP middle school mathematics classrooms. "Hands-on" learning involves using tools and materials to assist students to concretize abstract concepts. Toward this end, a few of the middle school math teachers used manipulatives, but none of the high school teachers did. About one-fourth of senior high and one-fifth of middle school teachers provided students with opportunities to use technology, such as calculators or computers. Teachers' limited use of technology in mathematics classrooms may be a result of lack of access to materials, resources, and/or knowledge of how to integrate the use of technology in their classroom.

Without the assistance and direction of how mathematical procedural knowledge is applied to "real world" problems, students may not be able to make those connections on their own. Applying mathematics to real world problems occurred much more frequently in comparison high school classrooms (50%) than in LAUSP high school classrooms (5%). More high school teachers (39%) than middle school teachers (29%) were observed to use relevant examples in their explanations of mathematical problems.

These findings are consistent with Stigler's (1997) supplement to the TIMSS study, which found that, in the majority of mathematics classrooms, students practiced routine procedures aimed at getting the right answer, rather than activities that demand mathematical reasoning and encourage students to apply their knowledge to new

situations. Overall, cognitive challenge was low. The activities administered to students in secondary mathematics classrooms did not involve problem-solving or inquiry skills reflective of more complex tasks nor did they involve using the tools or materials to assist them in translating the more abstract concepts of mathematics into concrete "real world" problems to solve.

In our interviews, teachers indicated the many challenges they routinely face in trying to bring up their students' skill base. The pressure of standardized tests tended to drive the curriculum away from the pacing plan and limited their ability to help students develop the higher level reasoning and mathematical understanding called for in the Standards. The pressures of accountability on these lower performing schools resulted in a curriculum driven by standardized tests and rapid coverage of the material outlined in the texts. Forces that could counterbalance the pressures of standardized tests were weak, at best. Teachers reported limited participation in professional development thus potentially preventing them from receiving the modeling and instructional support that a shift in practice requires. As one teacher put it,

> "There is so much pressure for good test scores which really cuts into teaching time itself, I mean they held out the carrot and the stick to us here at our school and last year we got very high numbers on our Stanford 9's and we were supposed to get some monetary rewards which philosophically I was opposed to because that throws open the door to cheating... [Now] they've taken away the carrot but and they're still holding the stick over our heads. They're telling us that if we do not perform next year we will be sanctioned. And I have a great opposition to that, I have a tremendous opposition because it basically gets us away from our subjects, we spend a lot of time in staff development trying to come up with ways to improve our Stanford 9 scores which actually cuts into the teaching of the academic subject that I do because we spend time teaching to prepare for that test and the high school exit examination."

Teachers reported that students were ill prepared for their courses and thus a portion of the year was spent trying to bring students' skills up to the level of the course. Teachers also voiced frustrations with district policies that eliminated the more basic math courses and increased eighth grade enrollment in Algebra courses, yet failed to provide the additional support students needed to succeed in those courses. One teacher presented the issue this way,

> "They [students] have been brought to my class, put in my class, and they are not ready for my class. And most of them aren't ready for the Algebra I-A-I, which is the same material at half the speed. So they do three chapters in a semester, instead of six. Most of them aren't ready for that, and yet they're in my class. And that is both a problem with our counselors, our middle schools, and the testing and screening of the students. And I've talked to some students who speak almost no English. I have some students who can't add 2 and 5 and get 7, without using their fingers. And they should not be in a fast-paced Algebra I-A class. Somewhere along the line, someone put them here, and this isn't where they belong."

Teachers acknowledged that in many cases, the issues they faced were due to students' limited English proficiency and, consequently, their class time was spent preparing students for the numerous high stakes tests or assisting them with strategies to narrow their options on the multiple choice tests. One teachers concludes,

> "If they have low reading skills I cannot read the question for them, so I have to give them tips and tools on how to get through each math story problem, look for certain words that will tell you how to do it and then throw out the ones that are real ridiculous and choose from the two answers that are closer to what the real answer is and you have a chance to use graph paper to figure it out. So and some students work fast, others work slow, some don't care and so they put any answer down."

While teachers' made concerted attempts to ensure students' understanding of the material, the pressure to cover the material confounded their ability to do so. The following teacher acknowledged the compromise he felt forced to make.

> "The pace is set by the district, not me, and I stick to that pretty much, because as far as I'm concerned, it's a double-edged sword. I can either slow down, make sure everybody gets it, but at the end of the semester, we're done with chapter four, and everybody technically fails, because we've only finished Chapter Four. Or, I go the pace the district sets, I get through all six chapters, and for better or worse, and I may lose some people along the way. Some people go the other way. I go this way. I decided that I would go with what the district asked me to."

Teachers' goals to enhance student performance on high stakes tests must also be examined in conjunction with the goals of assisting students to develop mathematical understandings. Examining other factors such as levels of engagement can serve to illustrate how the instructional strategies and student activities are not meeting the diverse educational needs of the students in these low-performing schools.

Student Engagement in Secondary Mathematics Classrooms

While lecturing may appear to be an effective method for the teacher to communicate information, unless teachers' closely monitor students' attention and involvement, they can often overlook those who are, in fact, completely disengaged. Turner and Meyer (1998) examined the conditions of classroom contexts that promote high psychological involvement of students and identified pro-engagement factors in teacher classroom discourse.[21] High engagement classrooms characteristically include teacher discourse that

[21] Turner, J.C. Meyer, D.K (1998) Creating contexts for involvement in Mathematics. Journal of Ed.Psych. 90(4)

presses students for understanding, student autonomy (decision-making), and problem solving activities.

Observers rated the classrooms on the level of student engagement. The teachers' scores were averaged across the three days. In some cases, observers noted that no time was actually devoted to instruction. At times, we observed high rates of "off-task" behavior or "off-topic" discussions occurring in the classrooms (Table 16).

In middle school classrooms, roughly half of the students were engaged in the lessons. At the high school level, student engagement was higher (63% comparison vs. 75% LAUSP). Off-task behavior took the form of students engaging in off-topic conversations, running around the classroom, or playing games that the teacher didn't seem to notice.

TABLE 16: MEASURES OF STUDENT ENGAGEMENT IN MATHEMATICS

	1	2	3	4	mean
Scale:	<50%	50%	85%	>85%	
LAUSP					
Middle	6%	41%	47%	6%	2.64
High	16%	21%	58%	5%	2.55
Comparison					
Middle	38%	12%	50%	0	2.15
High	0	25%	75%	0	2.92

Overall, we found very few classrooms with high levels of student engagement. With significant numbers of students' disengaged, teachers' may want to consider pedagogical approaches that better serve their students.

Teachers' participation in professional development may have an effect on the variety of approaches they use in the classroom. In secondary mathematics classrooms, teachers report that they did not receive instructional support, even though opportunities for support have been provided through the Districts' Math Plan. Nearly half of the middle school teachers and three-quarters of the high school teachers indicated they had no experience with a math coach.

Only half of the secondary math teachers participated in one or two professional development workshops, whereas 15% of the teachers in our study did not participate in any workshops (Table 17). The workshops that teachers mentioned were not necessarily those workshops provided through the LAUSP program.

TABLE 17: SECONDARY MATH TEACHERS PARTICIPATION IN PROFESSIONAL DEVELOPMENT WORKSHOPS

Professional Development Workshops

	Middle	High
No Workshop	3	4
1-2 Workshops	14	11
3 or more	4	5

*Not all teachers provided this information

If exposing teachers to a variety of instructional strategies will assist them to further develop students' mathematical understandings by providing models of how to teach mathematics courses that incorporate activities that go beyond teaching students basic computational skills, then these teachers would be better served by enhancing the support these schools are receiving. Only when teachers are provided opportunities to learn from other teachers and discuss effective strategies will they be able to assist students to both

raise achievement levels and student engagement with the subject matter. With exposure and lesson modeling, teachers' may be able to include activities in their lessons that aid students' development of reasoning and problem solving skills to further the application of procedural skills into greater mathematical understandings.

Instructional Strategies in Secondary Science Classrooms

Instructional strategies most commonly observed were lecture and teacher led whole class. In secondary science classrooms, discussions were more prevalent than in mathematics classrooms (see Table 18). While teachers' were frequently observed to utilize traditional instructional strategies, far more inquiry strategies were observed in the comparison

TABLE 18: INSTRUCTIONAL STRATEGIES IN SECONDARY SCIENCE CLASSROOMS

	LAUSP		Comparison	
Instructional Strategy	Middle (N=23)	High (N=21)	Middle (N=11)	High (N=8)
Traditional				
Teacher leads whole class	96%	76%	82%	88%
Lectures/presents a lesson	96%	76%	73%	75%
Circulates to provide assistance and feedback	65%	76%	82%	75%
Checks for prior learning	61%	62%	73%	63%
Inquiry-Based				
Leads a discussion	56%	38%	73%	38%
Asks for students to clarify, justify and explain answers	30%	43%	73%	100%
Summarizes main points at the end of activity	43%	19%	55%	13%
Asks open-ended questions	35%	48%	55%	100%
Categorizes information, compares, and contrasts	35%	29%	55%	25%
Proposes to students to conduct a study/research question	30%	29%	36%	25%

classrooms. Comparison teachers asked more open-ended questions and more frequently required students to clarify and explain their answers. Sixty-two percent of comparison teachers were observed to ask open-ended questions on all three days. Roughly half of the LAUSP high school science teachers asked students open-ended questions on one day or more.

Open-ended questions are those that require students to elaborate or explain a concept, to compare and contrast several possibilities, or to speculate about an outcome or explore cause and effect. Far more secondary science teachers than mathematics teachers posed open-ended questions. Despite the instances of open-ended questions, the classroom narrative data reveals that these questions did not often lead to extended content-rich classroom discussions.

Overall, however, the majority of questions teachers asked required only that students recall basic or newly acquired information (scored as a "one"). Most questions did not demand students to provide evidence or justification for their answers. This was true for teachers at middle schools (84%) and high schools (68%).

The following example demonstrates how a teacher used open-ended questions in a written assessment that required students to demonstrate higher-order thinking skills. In this example students were required to use reasoning skills, analyze differing points of view, provide evidence, and critique and evaluate information.

- The cost of the human genome project will be about $88 million per year for 15 years. Should the government spend money on this project? Why or why not.
- Some people say that knowing about our own personal genome could change the human population physiologically. How do you think the human population could change? What benefits could result from these changes?
- List 3 disadvantages of creating an expensive bank of criminal genome.

Observers found few opportunities for students to engage in discussions, particularly at the high school level (38% of teachers offered these opportunities). Discussions were observed more frequently among the middle school teachers, although the quality of those

discussions was low. Typically when conversations occurred they consisted of teachers posing low-demand, basic recall types of questions.

> T: What are the three layers of the earth?
> S: Core, Mantle, and Crust.
> The teacher draws a diagram of the earth's layers on the overhead.
> T: So, where does magma come from?
> S: The core.
> T: Exactly. Number 3, Which sentence best describes a volcano erupting?
> A boy reads the right answer, a sentence comparing an erupting volcano with a shaken-up bottle of cola being opened.
> T: What is this whole thing called? Look up here… (He holds up someone's poster). What is the whole thing called?
> One student raises her hand. Students call out answers.
> T: Electromagnetic radiation spectrum. Repeat it.
> The students repeat it 3 times after the Teacher. Teacher asks another student where the waves come from.
> S: Energy.
> T: That comes from where?
> S: Space.
> T: From space to earth. It's all forms of energy.
> (T has the students repeat him again. At least 90% of the students are participating).
> T: There's a portion called the optical- or the visible. What does that mean?
> Student: Like, you can see it.
> T: You can see it.

In this example students read out loud from the textbook while using a rotating oral reading strategy. During this time, the teacher interjected questions to reinforce the reading comprehension. Instructional strategies that encourage inquiry in a science classroom present science as problems to solve rather than as facts to memorize. Inquiry-related teaching has been effective in developing students' conceptual understanding, critical thinking and positive attitudes toward science.[22] While slightly more inquiry strategies were observed in science classrooms, the actual nature of these classrooms was not one in which students engaged in "hands-on" learning or one in which students conducted observations.

[22] Teaching science as inquiry. Rakow, (1986) Phi Delta Kappan (1986) Haury, (1993) Teaching Science Through Inquiry: ED 359048

Student Activities in Secondary Science Classrooms

While opportunities for "hands-on" learning occurred more frequently in science classrooms than in mathematics classrooms, most teachers did not have students conduct observations or engage in lab activities. Only 26% of the middle school teachers had their students conduct a laboratory (lab) experiment, and only one teacher conducted a lab twice or more. Lab activity occurred more often: In high school classrooms, 45% of the teachers conducted a lab at least once and 28% of the teachers conducted a lab on two or more days. Among high school science classrooms, we observed no differences between the two groups regarding the frequency of lab experiments (see Table 19).

TABLE 19: STUDENT ACTIVITIES IN SECONDARY SCIENCE CLASSROOMS

Student Activity	LAUSP		Comparison	
	Middle (N=23)	High (N=21)	Middle (N=11)	High (N=8)
Traditional				
Computational or procedural skills	13%	33%	27%	13%
Applied use of new vocabulary	43%	43%	100%	75%
Answering short one answer questions	83%	76%	73%	100%
Working individually	78%	62%	73%	75%
Worksheet	57%	52%	36%	63%
Inquiry				
Evidence of signs, symbols, models or graphs	35%	38%	55%	88%
Making observations	52%	48%	82%	50%
Asked to communicate reasoning, justify or explain	26%	29%	82%	100%
Applying skills to "real world" applications	9%	29%	55%	38%
Opportunity for hands-on learning	35%	57%	64%	63%
Asked to investigate/solve a problem, make a hypothesis	22%	29%	64%	38%
Collecting or recording data	22%	24%	36%	63%

More comparison than LAUSP teachers provided activities that required students to solve a problem. More than half of the comparison middle school teachers made attempts to assist students to use "real world" problems.

Observers found that in those classrooms where lab activity did not occur, the most frequent activity observed was reading. Fifty-nine percent of the middle school science teachers had students spend time reading on at least one day and 38% had students read twice or more during our three-day observation. In high school classrooms, 32% of the teachers engaged their students in a reading activity.

The bulk of the lessons in science classrooms were traditional activities. Students spent much time reading or working on worksheets individually at their desks. Students in the

comparison classrooms were learning or applying newly learned vocabulary in more than twice as many LAUSP classrooms.

One teacher commented that science at the middle school level consists primarily of learning vocabulary as opposed to process or inquiry skills.

> "What I really have found with both 7th and 8th grade curriculum, it is vocabulary, so much of science at this level is vocabulary."

"Effective" teachers incorporate and challenge students' prior knowledge, have them make predictions, allow them to test their ideas through experimentation, integrate their ideas and questions into the curriculum, facilitate a variety of "hand-on" experiences, and assign projects that include both reading and writing into the lesson.[23]

Asking students to communicate reasoning, justify or explain answers occurred far more frequently in the comparison classrooms. While more inquiry-based practices were observed in the high school classrooms, as indicated earlier, discussions were not prominent in most classrooms. Inquiry practices were more often incorporated within writing activities and less frequently seen in discussions. Observers noted that science journals were used in 15% of the middle school classrooms and in none of the high school classrooms. In high school classrooms, writing in science occurred occasionally when students were conducting a lab that included a "write up" or explanation of results or findings. Not all teachers conducting labs with their students included the "write up" as an essential component. As one teacher noted, just conducting a lab activity is not enough unless there is a written component to it for students to gain the most from the activity.

[23] Ornstein, (1995) Strategies for Effective Teaching, (1995) Brown and Benchmark

> "Doing a lab is following a recipe like a cookbook. It doesn't mean you learned anything. So the lab write-up shows me what they really learned from the lab."

Teachers' regretted the lack of lab activity occurring in the classroom. By way of explanation, they pointed to the lack of resources, inadequate facilities, and scarcity of textbooks, all of these limit teachers' ability to provide a coherent science program. As one teacher stated,

> We're not set for labs and we don't have the materials and the teachers have to do it out of pocket. We can't send the book home with them and say bring in this tomorrow, so we do the assignments in class and I have to give them something creative at home like look in the paper and find something or, you know, write a report on the planets but, you know, you can't send the textbook home with them, we haven't been able to do that yet.

Science teachers linked the difficulty in accessing resources to their inability to motivate students to continue to enroll in science courses. The following teacher lamented that science was not among the district's highest priorities.

> [It] would be helpful to have science workshops here because these students know they don't need science to graduate, you know, they have to pass English and math, those are required, and you get the feeling that even though science is important that the school mainly focuses on English and math, English and math, English and math, they get their textbooks first, the kids get textbooks assigned that they can take home, we still cannot send the students home with science books because we're last on the list.

This is not the case in all schools, but resources, whether computers, books, or the lab equipment necessary to conduct experiments, have been mentioned by numerous teachers as sorely lacking. Due to the absence of mandated testing in middle school and the heavy emphasis the district places on math, students are not receiving a coherent or consistent science program. In one instance, observers found middle school science teachers

switching their curriculum to teach math. They had been instructed to abandon their science curriculum to provide additional support in math prior to the SAT/9 exam.

Student Engagement in Secondary Science Classrooms

We looked at student engagement levels in science classrooms and found that in middle school classrooms where lab activity occurred there were higher levels of engagement. Consequently, in high school classrooms where lab activity occurred more frequently, a greater percentage of students were engaged. Far more of the middle school comparison classrooms had at least 85% of the students engaged, than did the LAUSP classrooms (see Table 20). Off-task behavior varied from class to class, but often took the form of students reviewing materials unrelated to the lesson, students getting up and roaming around the room, and in some cases students engaging in verbal assaults with one another, which typically led to teachers sending students out of the room.

TABLE 20: MEASURES OF STUDENT ENGAGEMENT IN SCIENCE

Scale:	1 (<50%)	2 (50%)	3 (85%)	4 (>85%)	mean
LAUSP					
Middle	26%	53%	21%	0	2.42
High	0	41%	53%	6%	2.82
Comparison					
Middle	0	13%	62%	25%	3.17
High	0	66%	33%	0	2.50

Classroom management issues often prevented teachers from believing that students could handle activities in which the teacher did conduct the class as a whole or lecture. Teachers' lack of confidence in their students may have contributed to the low level of cognitive challenge of the tasks assigned.

Although our sample of AP courses was small, observers noted distinct differences. In classrooms where teachers' confidence in students' abilities was high, the cognitive challenge of the tasks was greater. One observer summarized her three days in an AP science class as substantially different than the majority of classrooms she had observed.

> They covered complicated material in great depth, not only through lecture but with labs and review on all three days. The students were engrossed in the activities and they accomplished a lot during each class. The teacher connected each lab to real-world events, and had students working in small groups and responded to all their questions. The teacher also used materials that were more high tech, and he used a variety of materials."

Although there were more inquiry strategies observed in science classrooms, the more prevailing instructional pedagogy used was the whole class and lecture format. While this

may be the method of instruction teachers are most familiar with, it negatively impacts student engagement levels. In order for teachers to be exposed to a variety of instructional strategies they must have opportunities to learn and most of the teachers in our study had either not received or attended only one professional development workshop devoted to science.[24]

TABLE 21: SECONDARY SCIENCE TEACHERS PARTICIPATION IN PROFESSIONAL DEVELOPMENT WORKSHOPS

	Middle	High
No Workshop	10	7
1-2 Workshops	18	19
3 or more	7	6

*Not all teachers provided this information

Without sufficient exposure to and opportunities to observe models of inquiry-based lessons and strategies it is difficult to fault teachers for a lack of strategic transformation in their pedagogy. Without these opportunities to learn, teachers will not be able to effectively assist students to develop inquiry, problem solving and reasoning skills reflective of the Standards for both mathematics and science.

[24] These workshops were not necessarily those offered through the LAUSP.

Professional Development

The shift from traditional to inquiry-based practice requires an extensive level of support. School principals, district administrators, and teacher leaders are essential links in improving the quality of teaching and learning.[25] Support, guidance, and leadership are vital if teachers are to make major shifts from a traditional didactic style of teaching to one more reflective of the inquiry-based practices embedded in the Standards.

As teachers have mentioned in this report, they face numerous challenges as they work to align their content and instructional strategies in ways that help students attain the levels of understanding called for by the Standards. The demands are significant: Teachers must prepare students for the high stakes tests, cover the breadth of the material, and accommodate students of varying skill levels. In order for teachers to implement the Standards and teach students the inquiry and problem solving skills reflective of the disciplines of mathematics and science, they need opportunities to learn, instructional support, and models to become reflective about their own practice. Transforming teacher practice requires a commitment to professional development on the part of the principal, the teacher, and the district to provide the assistance and support teachers need.

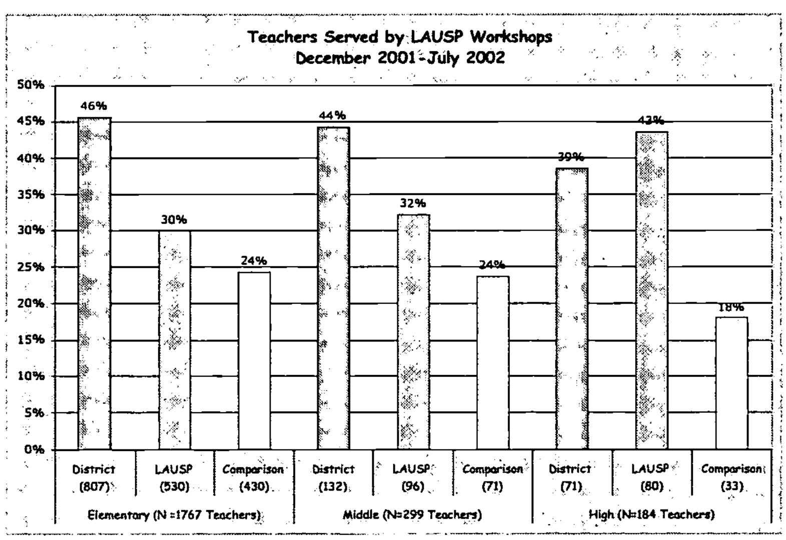
The LAUSP provides professional development workshops to both mathematics and science teachers. Ultimately, the effect of these efforts will be measured by students' improved achievement on standardized tests and other outcome measures. About 300 teachers attend these workshops on a monthly basis. Teachers attending these workshops

[25] Fullan, M. G. (1991). The New Meaning of Educational Change. New York: Teachers College Press

come from schools throughout the district; some are new to the workshops and some return monthly. Many of these workshops are conducted through the six Math/Science resource centers located throughout the district.

We found that the elementary and middle school LAUSP workshops held between December 2001- July 2002 included teachers from the targeted LAUSP schools, the comparison schools and the district at-large (see Figure 4). While LAUSP-sponsored workshops served thousands of mathematics and science teachers across the district, these reflect a small portion of all the teachers in the district teaching mathematics and science. Clearly, the majority of teachers served by the workshops were elementary teachers. They participated at twice the rate of middle school math and science teachers and between two and four times the rate of senior high school teachers. The number of LAUSP teachers who attended LAUSP workshops at elementary and middle school levels was proportional to each group's representation in the LAUSD population (9% and 4%,

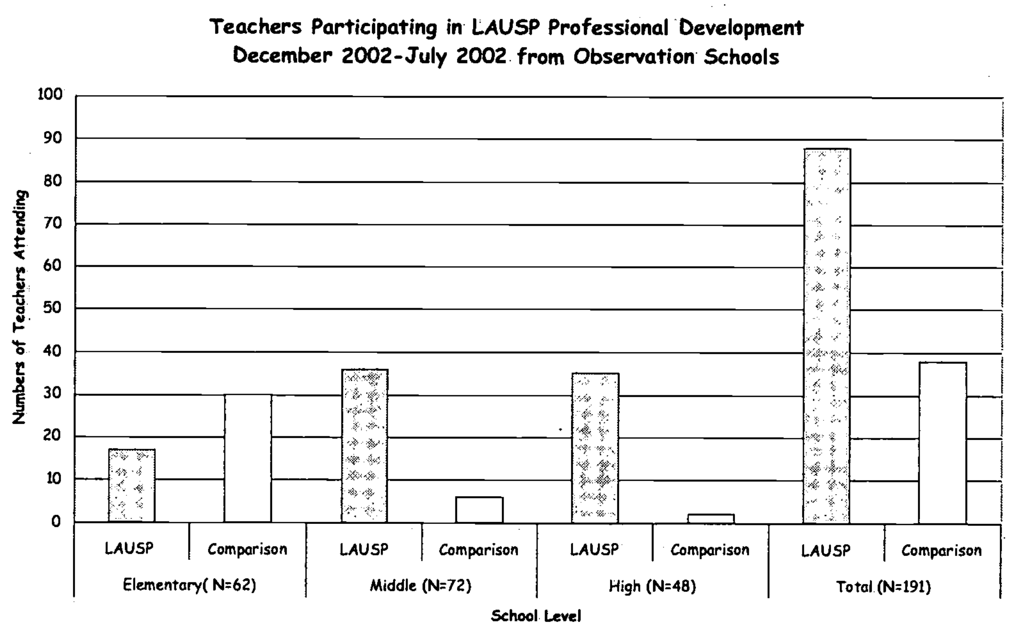
FIGURE 4: TEACHER PARTICIPATION IN PROFESSIONAL DEVELOPMENT WORKSHOPS



respectively, see Appendix D). While the high school teachers had the smallest number of attendees, the proportion of LAUSP high school teachers attending the LAUSP workshops was two to four times greater than for those attending from comparison schools or from the district at-large.

As the LAUSP project matured, the numbers of workshop attendees coming from LAUSP schools increased. Nearly half of the teachers who attended workshops in the latter part of the year came from LAUSP schools (see Figure 5). Given that we observed teacher practice during the first semester, we naturally missed any impact on practice occurring from professional development completed during second semester.[26]

FIGURE 5: TEACHER PARTICIPATION FROM OBSERVATION SCHOOLS IN LAUSP WORKSHOPS

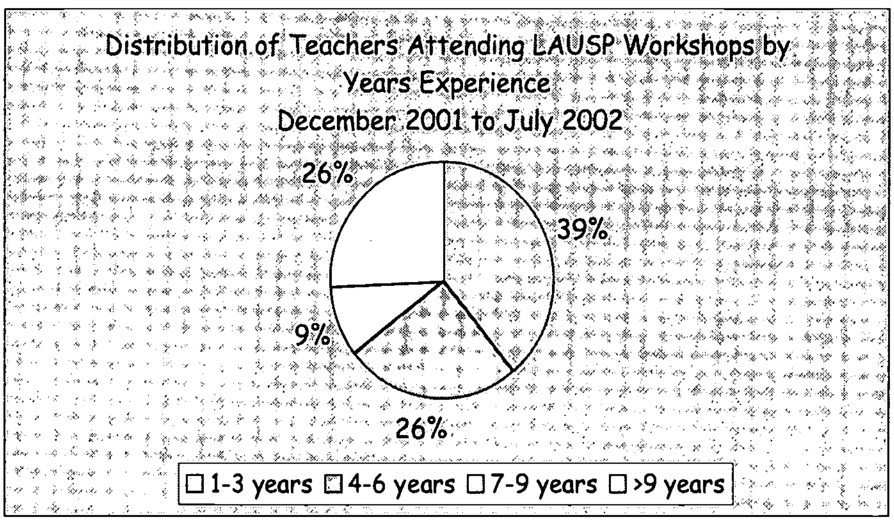


[26] Interview data collected from teachers only extended through May 2002, thus the LAUSP teachers could have attended more workshops from May through July that was not captured in the interview.

Therefore, the effect of these workshops on teacher practice will not be seen until we observe teachers next fall.

Data gathered from teacher participation at workshops also indicates that the majority of teachers served are those with more than 4 years teaching experience. Nearly 40% of the teachers attending the LAUSP workshops during the baseline year from December 2001-July 2002 were those with less than 4 years teaching experience (see Figure 6).

FIGURE 6: TEACHERS SERVED BY LAUSP WORKSHOPS BY YEARS EXPERIENCE



Among the teachers in our observation classrooms, the secondary teachers had fewer years teaching experience compared to the elementary teachers. More than half of the secondary teachers had less than 4 years teaching experience whereas only a quarter of the elementary teachers had less than 4 years teaching experience.

[27] Interview data collected from teachers only extended through May 2002, thus the LAUSP teachers could have attended more workshops from May through July that was not captured in the interview.

Math/Science Centers

Teachers were asked in interviews about their familiarity and use of the Math/Science resource centers located throughout the district. Among the secondary math and science teachers roughly half had used the centers for materials or workshops. The remaining teachers indicated that either they were not familiar with the centers or were familiar but had never visited or contacted the centers for any purpose.

Many teachers indicated that they appreciate what the centers have to offer, although some teachers mentioned that a few years ago they were more efficient and better equipped. Some teachers also commented that the distance and their busy schedules often prevented them from accessing the resources at the centers. One teacher noted,

> "Some of the centers are not close enough where you can stop by on your way home, and by the time we finish with our meetings, they are closed, and so I don't have time to get there."

Those teachers who do have centers within their vicinity indicated that they frequent them, as they lack resources at their schools. Those who cannot access the centers due to busy schedules or inconvenient hours settle for the equipment they can "piece together on their own".

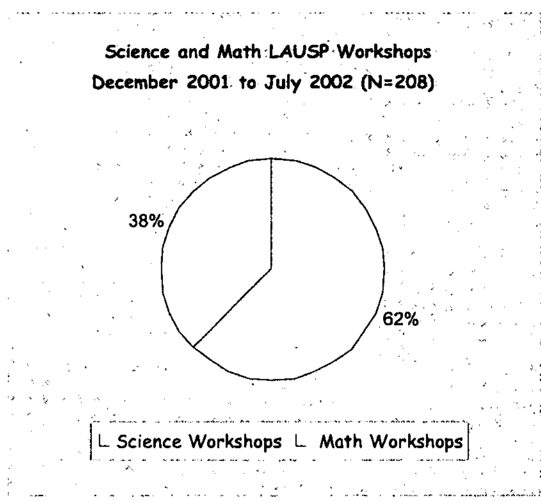
A majority of the LAUSP workshops are held at one of the math/science resource centers. Teachers' limited participation in professional development workshops may be attributed to two factors: distance to the location and awareness. Secondary math teachers mentioned that the availability of on-site professional development was limited. One

teacher noted that there had been a decline in the on- site professional development offered in science.

> "It used to be a little more frequently, maybe once a year, but in the last couple of years, seldom. There haven't been any professional development workshops offered at our school in the last two years, nor have I attended any elsewhere."

The LAUSP offered over 200 workshops from January 2001-December 2002. Two thirds of the workshops addressed science topics. The location of workshops held during the period from December 2001- July 2002 were as follows: two-thirds of the workshops were held at one of the science centers, 19% were held at a site other than the centers or a school site, 15% were held at a school site, and none were held at any of the 146 LAUSP schools.

FIGURE 7: DISTRIBUTION OF WORKSHOPS OFFERED BY SUBJECT



The coaching component of the District Math Plan was received by a limited number of teachers. Coaches were utilized more frequently at lower schooling levels. Twenty percent of the elementary, 45% of the middle and 75% of the high school teachers reported no experience with a mathematics coach. Some of the teachers receiving support from a math

coach were confused as to the role and purpose of the math coaches, as these teacher comments indicate.

> "Well, up until recently, I didn't understand what the position of the math coach consisted of. One of the difficulties with the math coach was that I believe the math coach came from the district, and so there was hardly any articulation as to what the math coach was to do with us. And so I've rarely seen a math coach in my classroom. She's come through maybe once or twice."
>
> "I put in a request to get assistance from the math coach, but she's got her hands full so it's hard. As you know, every teacher here could use some assistance, it's like there's just no time for her to get around to everybody."

Other teachers' comments reflected positive reactions to the support offered by the math coaches.

> "We have an excellent math coach, she will give us a sequence of subjects we should be covering and we kind of do long term planning, and so it kind of keeps you on track and gets you to where you need to be at the end of the year. Usually we would leave things like geometry and measurement for last and it was covered on the SAT/9 and we didn't get to it in time in the past, so now we're making sure to get those topics covered so the children will be prepared for the test."

Overall LAUSP professional development offered in the first year predominantly served elementary teachers, and the majority of those workshops focused on science. This finding suggests that when the districts' efforts shift to include a focus on science, those teachers may be better prepared.

Implementing the mathematics and science Standards requires a concentrated commitment to professional development that goes beyond the one-shot workshop and occasional buy-back day. Teachers need opportunities to practice, observe and analyze examples of effective teaching models. Teachers need to have examples and lessons

modeled for them that provide alternative instructional strategies so they can see what classrooms might look like when the Standards are implemented. The on-site support and feedback needed by teachers to become reflective on their own practice, to align curriculum, instruction and assessment must come from both the school level and the district level in order to see changes in the classroom. Research indicates that professional development yields the best results when it is long-term, school-based, collaborative, and focused on students' learning (Darling-Hammond & Sykes, 1999). Typically teachers need to find time to attend professional development workshops on Saturdays or after school or during their vacation breaks. In order for teachers to transform their practice, they need to engage in learning within workplace settings, observing and being observed by colleagues.

Recommendations

Overall LAUSP professional development offered in the first year predominantly served elementary teachers, and the majority of content addressed in those workshops focused on science. This finding suggests that when the districts' efforts shift to include a focus on science, those teachers may be better prepared.

Based on our findings we make the following recommendations:

1) If LAUSD desires science to be taught, especially at the early grades, the district needs to support standards-based science curriculum adoption and implementation. In doing so, the district will need to ensure availability of sufficient materials (books, lab materials, etc.). In elementary classrooms, the district should consider allotting a specific time devoted to science.

2) In order to assist the LAUSP in serving the professional development needs of mathematics and science teachers, the district should consider further supplementing LAUSP resources and staffing to ensure access for more of the districts' teachers to receive the professional development offered. This could happen by increasing the number of Math/Science resource centers to one per local district. Science coaches/specialists should also be considered.

3) The district should enforce the policy that students must pass two years of laboratory science and three years of mathematics prior to high school graduation.

4) The LAUSP should expand its professional development offerings to include on-site support to teachers, while maintaining the professional development offered to teachers at the Math/Science resource centers.

5) The LAUSP should increase the professional development for middle and high school teachers, particularly to teachers teaching Algebra in the eighth grade.

6) The LAUSP should offer professional development to principals in order to assist them in supporting teachers to align curriculum and instructional practice.

Appendices

APPENDIX A: BLOOM'S TAXONOMY *

Benjamin Bloom created this taxonomy for categorizing level of abstraction of questions that commonly occur in educational settings. The taxonomy provides a useful structure in which to categorize test questions, since professors will characteristically ask questions within particular levels, and if you can determine the levels of questions that will appear on your exams, you will be able to study using appropriate strategies.

Competence	Skills Demonstrated	Question Cues:
Knowledge	observation and recall of information knowledge of dates, events, places knowledge of major ideas mastery of subject matter	list, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
Comprehension	understanding information, grasp meaning, translate knowledge into new context interpret facts, compare, contrast order, group, infer causes predict consequences	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
Application	use information, use methods, concepts, theories in new situations, solve problems using required skills or knowledge	apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover
Analysis	seeing patterns ,organization of parts recognition of hidden meanings identification of components	analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer
Synthesis	use old ideas to create new ones , generalize from given facts relate knowledge from several areas ,predict, draw conclusions	combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what if?, compose, formulate, prepare, generalize, rewrite
Evaluation	compare and discriminate between ideas, assess value of theories, presentations make choices based on reasoned argument verify value of evidence recognize subjectivity	assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize

Adapted from: Bloom, B.S. (Ed.) (1956) Taxonomy of educational objectives: The classification of educational goals: Handbook I, cognitive domain. New York ; Toronto: Longmans, Green.

APPENDIX B: TEACHER QUESTIONING SCALE

Teacher Questioning Scale	
Recalling Knowledge (1)	Asks a yes or no question? Asks students to recall information
Make Connections (2)	Asks students to deduce relationships, analyze their own statements or assist students with different perspectives or points of view.
Encourages Students to make a claim (3)	Poses question that probe for reasoning and evidence. Help students become aware of underlying assumptions.
Encourages students to justify, critique or evaluate (4)	Asks students to defend or justify assertions, and critique or evaluate information.

APPENDIX C: QUALITY OF INSTRUCTION RUBRIC

GOALS

Clarity and Focus of the Teacher's Stated Goals on Student Learning

Do not rate the activities you observe, but rather the goals as articulated by the teacher.

☐ 1	☐ 2	☐ 3	☐ 4
Goals are not focused on student learning, goals are not clear and explicit in terms of what students are to learn from the assignment OR all goals may be stated as activities with no definable objective ("activity for activity's sake").	Goals are somewhat focused on student learning. Somewhat clear and explicit in terms of what students are to learn from the assignment. May be very broadly stated (e.g. reading comprehension). Or there may be a combination of learning goals and activities.	Goals are mostly focused on student learning. Goals are mostly clear and explicit in terms of what students are to learn from the assignment.	Goals are very focused on student learning. Goals are very clear and explicit in terms of what students are to learn from the assignment. Additionally, all the goals are elaborated.

ALIGNMENT

Alignment between Goals and Learning Activities (e.g. how well the activity promoted achievement of the teacher's goals)

☐ 1	☐ 2	☐ 3	☐ 4
There is very little or no alignment between teacher's stated goals and what the task asks students to do. The task does not support the instructional goals.	There is only some alignment between teacher's stated goals and what the task asks students to do. The task only somewhat supports the instructional goals.	There is good alignment between teacher's stated learning goals and what the task asks students to do. The task supports instructional goals.	There is exact alignment between teacher's stated learning goals for students on that assignment and what the task asks students to do. The task fully supports instructional goals.

COGNITIVE CHALLENGE

Consider both the content material and the way students are asked to engage with it.

☐ 1	☐ 2	☐ 3	☐ 4
Task does not require any degree of complex thinking and/or does not engage students with substantive content material. (e.g. , Students are asked to recall basic information in the form of short, "right" answers. Or student may be asked to answer simple	Task requires moderately complex thinking. Some substantive content area material may be covered. e.g. Students may be asked to summarize straightforward information, infer simple main idea, or simply apply the appropriate format for a given genre or problem they are asked to solve.	Task requires complex thinking. Student may also engage with substantive content material. e.g. Students may be asked to synthesize ideas; analyze cause and effect; identify a problem and pose reasonable solutions; hypothesize; speculate with details or justification; defend opinions or argue a position with evidence; evaluate; analyze (distinguishing important or relevant from	Task requires strongly complex thinking as an extensive, major focus of task. Student also engages with substantive content material. e.g. Students may be asked to develop an idea or theory, explore a scenario, or investigate a problem, present opinion or fact with evidence, evaluate and critique ideas and support claim

reading comprehension questions, write on a topic with little focus or structure.)		unimportant or irrelevant); determine bias, values, intent.	with arguments.

STUDENT ENGAGEMENT

Proportion of Students 'On-Task'

☐ **1**	☐ **2**	☐ **3**	☐ **4**
Fewer than half of the students appear to be on task.	Approximately half the students appear to be on task.	Approximately 85% of the students appear to be on task.	All students are engaged in the activities.

APPENDIX D: DISTRIBUTION OF TEACHERS SERVED THROUGH LAUSP WORKSHOPS

School Level (Total N)	Total # of Teachers Within Each Sub Group	% of Total
Elementary (20,846)	Neither (9303)	9%
	LAUSP (6204)	9%
	Comparison (5339)	8%
Middle (2316)	Neither (1056)	13%
	LAUSP (743)	13%
	Comparison (517)	14%
High (2015)	Neither (1092)	7%
	LAUSP (487)	16%
	Comparison (436)	8%